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ORIGINAL RESEARCH

Effectiveness of a Functional Rehabilitation Program for Upper Limb Apraxia in Poststroke Patients: A Randomized Controlled Trial

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Abstract

Objective: To analyze the effectiveness of a home-based restorative and compensatory upper limb apraxia (ULA) rehabilitation program.

Design: Randomized controlled trial.

Setting: Neurology Unit of San Cecilio Hospital and 2 private and specialized health care centers.

Participants: Community dwelling participants (N = 38) between the ages of 25 and 95 years old (sex ratio, 1:1) with unilateral mild-to-moderate poststroke lesions (time of evolution since stroke, 12.03±8.98mo) and secondary ULA.

Interventions: Participants were randomly assigned to an 8-week combined ULA functional rehabilitation group (n = 19) 3 days per week for 30 minutes or to a traditional health care education protocol group (n = 19) once a month for 8 weeks. Both interventions were conducted at home.

Main Outcome Measures: Sociodemographic and clinical data, Barthel Index (primary outcome), Lawton and Brody Scale, observation and scoring activities of daily living, the De Renzi tests for ideational and ideomotor apraxia and imitating gestures test, recognition of gestures, test for upper limb apraxia , and stroke-specific quality of life scale were assessed at 3 time points: baseline, posttreatment (8wk), and follow-up (8wk).

Results: There were statistically significant differences among the groups regarding ideomotor apraxia, imitating gestures, global recognition of gestures, intransitive gestures, and comprehension of gesture production ($P<.05$) in favor of the experimental group. However, no statistically significant differences were found between the groups regarding functionality or quality of life ($P>.05$). Regarding the within-group effect, statistically significant differences were found in all neuropsychological outcomes at posttreatment and follow-up ($P<.05$).

Conclusion: A functional rehabilitation program was found to be superior to a traditional health care education program and resulted in improvements in neuropsychological functioning in ULA poststroke. Conventional education showed an insufficient effect on apraxia recovery. Further studies with larger sample sizes are needed to determine the effect of rehabilitation strategies on functionality and quality of life of poststroke ULA patients.

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Although the mortality rate associated with stroke has decreased, stroke remains a public health problem due to the aging of the population and the increased prevalence of stroke survivors with greater levels of disability.[1] The American Heart Association places stroke as the fifth highest cause of death worldwide, and stroke is expected to be a major cause of long-term disability in the future.[2] Upper limb dysfunction is a significant contributor to disability. As many as 75% of

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poststroke patients experience it and up to one-third require ongoing care.[3]

Brain damage of vascular etiology, especially after a left hemispheric stroke, is frequently associated with apraxia.[4-6] Upper limb apraxia (ULA) comprises a wide spectrum of higher motor disorders, with an effect on the upper extremity ability to perform previously learned functional movements.[7-10] ULA cannot be explained by intellectual deterioration, deficits of comprehension, uncooperativeness, or a deficit in the elemental motor or sensory system.[11]

ULA can have a negative effect on occupational performance and significantly reduces independence in activities of daily living (ADL).[5] Efficient, cost-effective, and evidence-based intervention strategies are needed.[12] Currently, there are 2 interventions for rehabilitation treatment described in the scientific literature: restorative and compensatory.[13-18]

This study was developed based on evidence on the rehabilitation of cognitive functioning of ULA poststroke patients, which can improve the recognition and performance of transitive gestures involving the use of objects, and intransitive gestures without object use, both of which usually have nonverbal communicative value.[19] Praxis skills play an important role in functional performance, and their improvement can lead to ADL improvement. Moreover, follow-up evaluations suggest that praxis skills could provide long-term treatment benefits.[14,15] Compensatory strategies through ADL training are effective for poststroke ULA. An 8-week rehabilitation treatment based on integrating specific strategy training into the usual occupational therapy (OT) showed greater effectiveness in improving ADL-functioning than usual therapy alone.[5] Although previous studies have shown clinical benefits of ULA treatment, it is necessary to perform studies with a strong methodology to establish empirical causality, as well as to generalize the results to patients' ADL.[14] Only a few studies conducted to investigate ULA treatment efficacy have been randomized controlled trial (RCTs), and scarce data have been obtained from rigorously designed studies with sufficient sample sizes.[20,21] To our knowledge, no studies have been reported using a combined intervention approach, in which participants received specific ULA cognitive training in combination with a method that focused on the strategies needed to promote ADL functional performance at home.

The hypothesis of this study was that a combined, restorative, and compensatory approach might produce positive effects on the functional performance, neuropsychological function, and quality of life (QOL) in ULA poststroke patients. The overall objective was to analyze the effectiveness of a home-based restorative and compensatory ULA rehabilitation program in comparison with a control group that received a traditional health care education protocol (THEP).

List of abbreviations:

ADL	activities of daily living
BI	Barthel Index
IADL	Instrumental Activities of Daily Living scale
MANOVA	multivariate analysis of variance
OT	occupational therapy
QOL	quality of life
RCT	randomized controlled trial
SSQOL-38	stroke-specific quality of life scale
THEP	traditional healthcare education protocol
TULIA	test for upper limb apraxia
ULA	upper limb apraxia

Methods

Research design

An RCT was conducted between May 2014 and September 2018. The study was approved by the Research Ethics Committee of Granada province-CEI (Andalusian Health Service, Granada, Spain, 180SP), in compliance with the 2013 amendment of the Declaration of Helsinki[22] and current Spanish legislation for RCTs.[23] Methods and design details have been published previously by Pérez-Mármol et al.[12]

Participants

A total of 46 community dwelling participants were initially recruited from the Neurology Unit of San Cecilio Hospital (Granada, Spain). Due to problems with the recruitment of the study sample, we expanded recruitment to private and specialized health care institutions. Ultimately, 38 participants (sex ratio, 1:1) with clinical evidence of unilateral poststroke lesions and an average time of evolution of 12.03±8.98 months since the stroke met the inclusion criteria and were randomly assigned into 2 groups. Written informed consent was obtained from all participants.

Eligibility criteria

The inclusion criteria were (1) age between 25 and 95 years; (2) mild-to-moderate stroke effects 2 months after the episode (neurologic examination and National Institutes of Health stroke scale;[24,25] and (3) presence of ULA lasting at least 2 months, as defined by a score of 9 or less on the test for upper limb apraxia (TULIA).[16] The exclusion criteria were (1) a history of apraxia predating the current stroke, (2) having a stroke less than 2 months or more than 24 months previously, (3) cognitive impairment (Mini-Mental State Examination),[26] (4) severe aphasia, (5) previous brain tumor, (6) history of neurologic disorders, (7) did not speak Spanish, (8) drug addiction, (9) intellectual or learning disorder, (10) traumatic brain damage or neurodegenerative process, (11) impairment of awareness, or (12) orthopedic or disabling conditions.

Randomization and blinding

Participants were randomly allocated into 2 groups (ratio, 1:1), either a combined functional rehabilitation group or a control group, using a computational random number generator (EPIDAT 3.1).[a] MCGR created the randomization codes. A neurologist (F.J.B.H.) examined the eligibility criteria and registered the sociodemographic variables but was not involved further. Treatment allocations were concealed, and patients and study personnel were blinded after the database was locked. Throughout the trial, 3 therapists (J.M.P.M., R.M.T.H., and A.C.B.) were responsible for collecting all outcome measures and were blinded to group allocations. An occupational therapist with broad clinical experience performed the treatment and was also blinded to the outcome measures and baseline examination findings, but not to the

patients' treatment allocation. The occupational therapist did not know who collected the outcome measure data.

Interventions

Combined functional rehabilitation

The experimental group received OT for ULA management at home based on restorative (2 sessions/wk) and compensatory (1 session/wk) approaches, each supported by evidence of previous effectiveness.[13,14,17] The occupational therapist studied the capacities and limitations in daily performance to identify the patients' needs. This treatment not only aimed to improve independence at home, but also to improve functioning in other contexts.

The restorative approach[13,14,17] was composed of 3 sections, including transitive, intransitive-symbolic, and intransitive-nonsymbolic gestures. The difficulty level gradually increased, and patients were expected to reproduce the correct gesture. Each phase contained 20 gestures. When patients were able to perform at least 17 of the gestures, that phase was concluded and the next phase was started. The intervention ended when the patient adequately completed the 3 intervention sections or reached 35 sessions. In our study, when the functioning did not improve, we provided skills and strategies to enhance environmental adaptation and increase independence. All the gestures included in the experimental training were different from the evaluation items.

THEP

The control group received a THEP consisting of an educational workshop for patients and caregivers in which they were taught the implications of stroke and ULA. The workshops took place once a month over a 2-month period at the patient's home. After the control intervention period, participants were offered the opportunity to receive the experimental treatment.

Outcome measures

We collected all outcome measures at 3 time points: baseline, posttreatment (8wk), and follow-up (8wk). The Barthel Index (BI)[27] was the primary outcome used to assess functional disability in basic ADL. The secondary outcome measures were the Lawton and Brody Instrumental Activities of Daily Living (IADL) scale,[28] observation and scoring of ADL activities,[29,30] the De Renzi test for ideational and ideomotor apraxia,[31] the De Renzi imitating gestures test,[32] an assessment of recognition of gestures,[14] the TULIA,[33] and the stroke-specific quality of life scale (SSQOL-38).[34] All outcome measures were standardized and validated for poststroke patients, showing adequate psychometric properties. The recognition of gestures assessment was developed ad hoc by Smania et al.[14] Full access to the evaluation protocol is available from Pérez-Mármol et al.[12]

Sample size

Based on previously published findings on ULA poststroke rehabilitation,[5] a clinically relevant difference pre-post treatment of 2.44 points on the BI was used to calculate the sample size necessary to detect an increase in functional ability by undergoing combined functional rehabilitation vs THEP, using Power Analysis and Sample Size software (PASS 13).[b] It was determined that 15 participants per arm was the sample size estimated to provide a 95% confidence interval with a power of 80%, assuming a SD of

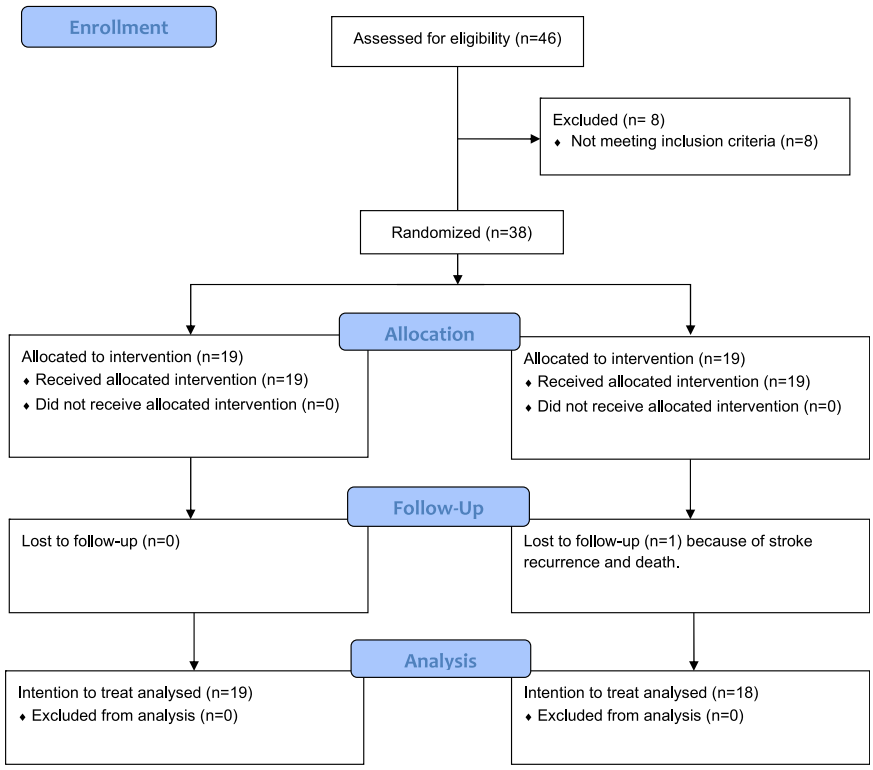

Fig 1 Flow diagram of the study participants following CONSORT guidelines for intervention-control.

3.10 points for this difference and a 2-sided test (α) of 0.05. The sample size was increased to 40 to allow for a 22% dropout rate.

Statistical analysis

SPSS 20.0[c] for Windows was used for the statistical analyses. After normal distribution was verified for all variables, a 2-way mixed model multivariate analysis of variance (MANOVA) was used to determine any differences between the mean change scores of groups regarding BI (primary outcome), as well as IADL scale, observation and scoring ADL, De Renzi tests, recognition of gesture, TULIA, and SSQOL-38 as secondary outcomes over time (baseline, posttreatment, and follow-up). All analyses followed the intention-to-treat principle, and the groups were analyzed as they were randomized. When the MANOVA demonstrated a significant effect ($P<.05$), a follow-up univariate analysis of variance (2-way mixed model) was performed with a Bonferroni adjusted P values to protect against the possibility of type I error. Changes in variable scores within and between groups were measured as mean (95% confidence interval). The effect size was calculated according to the Cohen d statistic. A P value less than .05 was considered significant in all tests.

Results

Thirty-eight participants met the inclusion criteria and were randomly assigned to the experimental (n=19) and control (n=19) groups. A CONSORT flow diagram of the participants throughout the study is shown in figure 1. Baseline sociodemographic characteristics were similar between groups for all variables (table 1). Mixed design multivariate analysis showed a statistically significant multivariate effects for groups (Wilks' $\lambda=.126$; F=6.68; $P<.001$) and for the interaction between groups and time (Wilks' $\lambda=.163$; F=1.421; $P=.036$).

General functionality and autonomy

The univariate analysis of variance did not find significant changes across the 3 timepoints evaluated for the total score of the BI (F=.143; $P=.867$), for the IADL scale (F=.092; $P=.912$), or for the observation and scoring ADL test (F=.039; $P=.962$). The results of the between-groups effect showed no statistically significant differences among groups regarding BI, IADL, or the observation and scoring ADL test. Within-group comparisons revealed significant improvements from baseline to posttreatment in the experimental group in total BI score ($P=.014$). The control group also showed significance for feeding ($P=.015$) at follow-up. Moreover, the within-groups analysis found significant differences for the transport subscale of the IADL in both groups at the end of the follow-up: experimental ($P=.042$) and control ($P=.020$). Lastly, the within-groups analysis found significant improvements from baseline to follow-up in the total observation and scoring ADL test (posttreatment, $P=.002$; follow-up, $P=.006$), hygiene items (posttreatment, $P=.020$; follow-up, $P=.020$), and relevant activity (posttreatment, $P=.013$; follow-up, $P=.007$) for the experimental group. Significant differences were also observed for dressing ($P=.017$) and feeding ($P=.045$)

Table 1 Sociodemographic and clinical characteristics of the sample of patients after stroke of vascular etiology

Outcomes	Statistic	Experimental Group (n=19)	Control Group (n=19)	*P* Value
Age, y	Mean ± SD	74.42±9.57	75.26±11.90	.811
	Median (minimum, maximum)	74 (54, 91)	76 (50, 93)	
Time since last stroke, mo	Mean ± SD	11.58±8.42	12.88±8.69	.658
	Median (minimum, maximum)	8 (2, 24)	12 (2, 24)	
Sex	Frequency (%)			.194
Male		7 (36.8)	12 (63.2)	
Female		11 (57.9)	8 (42.1)	
Right handedness	Frequency (%)	19 (100)	19 (100)	1.00
Localization of the damage	Frequency (%)			.452
Right		8 (42.1)	9 (47.4)	
Left		10 (52.6)	7 (36.8)	
Medial		1 (5.3)	3 (15.8)	
Stroke type	Frequency (%)			.631
Ischemic		17 (89.5)	2 (84.2)	
Hemorrhagic		16 (10.5)	3 (15.8)	
Severity of damage	Frequency (%)			.904
Mild		9 (47.4)	9 (47.4)	
Moderate		6 (31.6)	5 (26.3)	
Severe		4 (21.1)	5 (26.3)	
Recurrent stroke?	Frequency (%)			.485
Yes		12 (63.2)	14 (73.7)	
No		7 (36.8)	5 (26.3)	

NOTE. Data are expressed as mean ± SD for quantitative variables and as absolute frequency and % for qualitative variables. *P* values are associated with *t* tests for independent samples for continuous variables and chi-square tests for categorical variables; $P<.05$; $P<.005$.

Table 2 Baseline, posttreatment, and follow-up differences and change scores in each group (95% confidence interval) for functional independence in basic and instrumental ADL and disability provoked by apraxia

Outcome/Group	Baseline	Posttreatment, 8 wk	Follow-up, 8 wk	Cohen's *d*	Within-Group Score Change	Between-Group Score Change
BI total						
Experimental	68.42±27.74	74.21±26.10	73.42±27.84	0.18	−5.00 (−10.206, .206)	−.556 (−7.46, 6.35)
Control	67.37±25.95	69.72±25.29	71.39±23.75	0.16	−4.44 (−9.335, .447)	
Feeding						
Experimental	7.63±2.57	8.16±2.48	8.42±2.39	0.32	−.789 (−1.692, .113)	1.155 (−.52, 2.83)
Control	6.84±2.99	7.78±2.56	8.61±2.30	0.66	−1.944 (−3.455, −.433)	
Bathing						
Experimental	1.58±2.39	1.84±2.48	1.84±2.48	0.11	−.26 (−.816, .290)	−.26 (−.81, .29)
Control	1.05±2.09	.83±1.92	1.11±2.14	0.03	-	
Dressing						
Experimental	5.79±4.17	6.05±4.28	5.79±4.49	0.00	.000 (−.803, −.803)	.00 (−1.38, 1.38)
Control	5.26±3.11	5.56±3.38	5.28±3.20	0.01	.000 (−1.206, 1.206)	
Grooming						
Experimental	3.95±2.09	4.47±1.58	3.95±2.09	0.00	.000 (−1.136, 1.136)	.00 (−1.78, 1.78)
Control	3.68±2.26	4.17±1.92	3.61±2.30	0.03	.000 (−1.477, 1.477)	
Bowels						
Experimental	8.68±3.27	8.68±2.81	8.95±2.68	0.09	−.263 (−.816, .290)	.29 (−.93, 1.52)
Control	8.16±3.80	8.61±3.35	8.61±3.35	0.13	−.556 (−1.728, .617)	
Bladder						
Experimental	6.84±3.42	7.63±3.06	7.37±3.06	0.16	−.526 (−1.632, .579)	.03 (−1.52, 1.58)
Control	7.63±3.86	7.22±3.92	8.06±3.49	0.12	−.556 (−1.728, .617)	
Toilet use						
Experimental	6.84±3.80	7.63±3.86	7.73±3.86	0.33	−.526 (−1.286, .234)	−.25 (−1.48, .98)
Control	7.11±3.84	7.22±3.92	7.50±3.54	0.11	−.278 (−1.313, .757)	
Transfers						
Experimental	12.11±4.19	12.63±3.86	12.37±4.52	0.06	−.263 (−1.238, .712)	.33 (−1.75, 2.40)
Control	11.58±5.28	11.39±5.64	12.94±3.98	0.29	−.588 (−2.597, 1.420)	
Mobility						
Experimental	10.26±6.12	11.58±5.54	11.58±5.54	0.23	−1.316 (−3.083, .452)	−.76 (−2.98, 1.46)
Control	10.79±5.59	11.39±4.47	11.39±4.47	0.22	−.556 (−2.005, .894)	
Stairs						
Experimental	4.74±3.90	5.53±4.05	5.79±4.17	0.26	−1.053 (−2.343, .237)	−1.05 (−2.56, 0.46)
Control	5.26±3.90	5.56±4.16	5.00±3.84	0.07	.000 (−.853, .853)	
Lawton and Brody total						
Experimental	3.53±3.26	4.16±3.48	4.21±3.54	0.20	−.68 (−1.46, .09)	−.41 (−1.61, .80)
Control	2.58±2.04	2.67±1.88	2.78±1.99	0.10	−.28 (−1.27, .71)	
Ability to use phone						
Experimental	.79±.42	.79±.42	.79±.42	0.00	.00 (−.16, .16)	−.06 (−.31, .20)
Control	.84±.38	.78±.43	.78±.43	0.15	.06 (−.15, .26)	
Shopping						
Experimental	.32±.48	.37±.50	.42±.51	0.20	−.11 (−.26, .05)	−.11 (−.38, .17)
Control	.11±.32	.06±.24	.11±.32	0.00	.00 (−.24, .24)	
Food preparation						
Experimental	.32±.48	.42±.51	.42±.51	0.20	−.11 (−.26, .05)	−.16 (−.41, .08)
Control	.16±.38	.17±.38	.11±.32	0.14	.06 (−.15, .26)	
Housekeeping						
Experimental	.42±.51	.53±.51	.47±.51	0.10	−.05 (−.16, .06)	.06 (−.19, .30)
Control	.32±.48	.28±.46	.39±.50	0.14	−.11 (−.35, .12)	
Laundry						
Experimental	.42±.51	.53±.51	.53±.51	0.22	−.11 (−.26, .05)	.06 (−.22, .34)
Control	.16±.38	.28±.46	.33±.49	0.39	−.17 (−.42, .09)	
Mode of transport						
Experimental	.26±.45	.47±.51	.47±.51	0.44	−.21 (−.41, -.01)	.07 (−.23, .36)
Control	.26±.45	.56±.51	.56±.51	0.62	−.28 (−.51, -.05)	

(*continued on next page*)

Table 2 (*continued*)

Outcome/Group	Baseline	Posttreatment, 8 wk	Follow-up, 8 wk	Cohen's *d*	Within-Group Score Change	Between-Group Score Change
Responsibility of own medication						
Experimental	.47±.51	.53±.51	.53±.51	0.12	−.05 (−.16, .06)	−.11 (−.26, .05)
Control	.21±.42	.11±.32	.11±.32	0.27	.06 (−.06, .17)	
Ability to handle finances						
Experimental	.53±.51	.53±.51	.58±.51	0.10	−.05 (−.16, .06)	−.05 (−.30, .20)
Control	.53±.51	.56±.51	.50±.51	0.06	.00 (−.24, .24)	
Observation and scoring of ADL						
Experimental	18.26±14.69	14.84±14.51	15.05±14.86	0.22	3.21 (1.05, 5.38)	2.04 (−1.09, 5.18)
Control	18.37±13.32	16.56±12.12	16.67±12.09	0.13	1.17 (−1.27, 3.60)	
Personal hygiene						
Experimental	5.58±5.37	4.63±4.87	4.63±4.87	0.19	.95 (.17, 1.73)	1.00 (−.39, 2.39)
Control	5.37±4.27	5.00±3.74	5.28±3.98	0.02	−.06 (−1.29, 1.18)	
Dressing						
Experimental	4.95±4.74	4.37±4.78	4.58±4.98	0.08	.37 (−.19, .93)	−.19 (−1.45, 1.07)
Control	4.74±4.36	3.83±3.99	4.00±3.91	0.18	.56 (−.65, 1.76)	
Feeding						
Experimental	3.00±2.65	2.42±2.32	2.42±2.50	0.23	.58 (−.07, 1.23)	.25 (−.69, 1.18)
Control	3.21±3.79	3.22±3.41	3.06±3.24	0.04	.33 (−.39, 1.06)	
Relevant activity						
Experimental	4.63±3.77	3.47±3.61	3.42±3.58	0.31	1.21 (.37, 2.05)	.88 (−.05, 1.80)
Control	5.05±4.40	4.50±4.12	4.33±3.94	0.17	.33 (−.08, .75)	

NOTE. Values are expressed as means ± SD for baseline, 2 months posttreatment, and 2 months follow-up and as mean (95% confidence interval) for within (baseline to follow-up) and between-group change scores (at follow-up). Significant Group × Time interaction (MANOVA, $P<.05$).

at posttreatment, but this effect was not maintained at follow-up. No changes were found in observation and scoring ADL in the control group (table 2).

Neuropsychological tests

At the end of the follow-up period, the univariate analysis of variance revealed statistically significant differences in total score values of the De Renzi test ($F=5.212$; $P=.007$) and on the subscale for ideomotor apraxia ($F=5.163$; $P=.007$). Additionally, this analysis also found significant changes in the total score for De Renzi imitation gestures test ($F=11.256$; $P<.001$) and its subscales for symbolic finger sequence ($F=5.405$; $P=.006$), nonsymbolic finger position ($F\geq3.172$; $P\leq.046$), symbolic hand position and sequence ($F\geq4.687$; $P\leq.011$), and nonsymbolic hand position ($F=9.397$; $P\leq.001$). Finally, univariate analysis showed a similar effect for recognition of gestures total score ($F=3.852$; $P=.024$), intransitive gestures subscale ($F=6.463$; $P=.002$), and the TULIA test ($F\geq3.583$; $P<.031$).

The between-groups analysis showed significant differences, and therefore better scores, for the experimental group in the total score for De Renzi (posttreatment, $P=.005$; follow-up, $P=.001$), the ideomotor apraxia subscale (posttreatment, $P=.004$; follow-up, $P=.001$), the De Renzi imitation gestures total score (posttreatment, $P=.001$; follow-up, $P=.001$) and its subscales for symbolic finger sequence (follow-up, $P=.024$), nonsymbolic finger position (posttreatment, $P<.001$; follow-up, $P=.004$), symbolic hand position (follow-up, $P=.007$) and sequence (posttreatment, $P=.033$; follow-up, $P=.016$) and nonsymbolic hand position (posttreatment, $P=.001$; follow-up, $P<.001$) and sequence (posttreatment, $P=.026$). Within-groups comparison from baseline to follow-up values were significant for De Renzi total score (posttreatment, $P<.001$; follow-up, $P<.001$), the ideomotor apraxia subscale (posttreatment, $P<.001$; follow-up, $P<.001$), De Renzi imitation gestures test (posttreatment, $P\leq.015$; follow-up, $P\leq.014$), recognition of gestures test total score (posttreatment, $P<.001$; follow-up, $P=.002$), intransitive gestures subscale (posttreatment, $P<.001$; follow-up, $P=.001$), and TULIA (posttreatment, $P\leq.026$; follow-up, $P\leq.001$) in the experimental group. No changes were found in the control group for any of the reported outcomes (table 3).

Overall QOL

Follow-up univariate analysis of variance did not find significant differences in the total score of the SSQOL-38 ($F=.654$; $P=.522$). The results of the between- and within-groups effect showed no statistically significant differences among groups for this outcome (table 4).

Discussion

This study showed that an 8-week intervention focused on 2 complementary approaches for ULA (restorative and compensatory) produced improvements in neuropsychological function, with significant changes posttreatment and at the follow-up. However, the THEP group showed limited benefits. Therefore, our findings provide evidence on the superiority of the rehabilitation treatment compared with THEP for ULA.[19,35]

The results obtained for functionality showed no effect on basic or instrumental ADL for the combined functional rehabilitation

Table 3 Baseline, posttreatment, follow-up differences and change scores in each group (95% confidence interval) for ideational and ideomotor apraxia, movement imitation, gesture production, and recognition of gestures

Outcome/Group	Baseline	Posttreatment, 8 wk	Follow-up, 8 wk	Cohen's *d*	Within-Group Score Change	Between-Group Score Change
Ideational and ideomotor apraxia total						
Experimental	27.00±3.15	31.00±2.75	33.00±2.75	2.03	−4.42 (−6.22, −2.62)	−4.37 (−6.51, −2.23)*
Control	28.00±3.25	27.50±3.71	27.50±3.62	0.15	−.06 (−1.31, 1.20)	
Ideational						
Experimental	14.00±.69	14.00±.00	13.00±3.04	0.45	−.16 (−.49, .17)	−.16 (−.49, .17)
Control	14.00±1.21	14.00±1.24	14.00±1.24	0.00	-	
Ideomotor						
Experimental	13.00±3.04	17.00±2.36	19.00±2.75	2.07	−4.16 (−6.02, −2.30)	−4.10 (−6.30, −1.91)*
Control	14.00±3.13	13.50±3.68	13.50±3.52	0.15	−.06 (−1.31, 1.20)	
Movement imitation gestures test total						
Experimental	50.37±8.71	63.05±8.08	64.16±8.28	1.62	−13.79 (−17.72, −9.86)	−15.62 (−20.41, −10.84)*
Control	55.95±7.40	53.39±7.55	53.72±8.99	0.27	1.83 (−1.12, 4.78)	
Finger, position, symbolic						
Experimental	7.26±1.76	7.89±2.16	8.37±2.06	0.58	−1.11 (−1.95, −.26)	−1.11 (−2.05, −.16)
Control	8.00±1.20	7.67±1.24	7.94±1.31	0.05	.00 (−.45, .45)	
Finger, position, nonsymbolic						
Experimental	6.05±1.47	7.79±1.13	7.79±1.40	1.21	−1.74 (−2.55, −.92)	−1.68 (−2.88, −.48)*
Control	6.26±2.42	5.78±1.70	6.17±1.79	0.04	−.06 (−1.00, .89)	
Finger, sequence, symbolic						
Experimental	6.79±1.78	8.32±1.46	8.42±1.22	1.07	−1.63 (−2.41, −.86)	−1.91 (−2.83, −.99)*
Control	7.68±1.34	7.44±1.20	7.33±1.57	0.24	.28 (−.26, .81)	
Finger, sequence, nonsymbolic						
Experimental	4.84±2.00	6.58±1.74	6.47±1.98	0.82	−1.63 (−2.65, −.61)	−2.08 (−3.20, −.95)*
Control	5.84±1.98	5.44±2.28	5.44±2.06	0.20	.44 (−.07, .96)	
Hand, position, symbolic						
Experimental	7.84±1.86	8.95±.23	9.00±.00	0.88	−1.16 (−2.06, −.26)	−1.55 (−2.60, −.50)*
Control	8.42±1.02	8.50±1.04	8.00±1.53	0.32	.39 (−.21, .98)	
Hand, position, nonsymbolic						
Experimental	4.95±1.84	7.32±1.16	7.84±1.12	1.90	−2.90 (−3.74, −2.05)	−3.28 (−4.41, −2.15)*
Control	5.63±2.11	5.22±2.24	5.11±2.03	0.25	.39 (−.41, 1.19)	
Hand, sequence, symbolic						
Experimental	7.42±1.68	8.63±.83	8.74±.73	1.02	−1.32 (−2.07, −.56)	−1.54 (−2.68, −.39)*
Control	8.00±1.11	7.89±1.18	7.78±1.48	0.17	.22 (−.71, 1.15)	
Hand, sequence, nonsymbolic						
Experimental	5.68±1.95	7.58±1.68	7.53±1.71	1.01	−1.84 (−2.76, −.93)	−1.95 (−3.00, −.90)
Control	6.32±2.29	6.06±2.29	6.22±2.39	0.04	.11 (−.45, .67)	
TULIA total						
Experimental	188.53±30.04	219.53±24.06	224.26±18.89	1.42	−35.74 (−46.79, −24.68)	−35.40 (−51.00, −19.81)*
Control	206.84±23.67	208.67±19.12	205.61±30.76	0.04	−.33 (−12.17, 11.50)	

(*continued on next page*)

Table 3 (*continued*)

Outcome/Group	Baseline	Posttreatment, 8 wk	Follow-up, 8 wk	Cohen's *d*	Within-Group Score Change	Between-Group Score Change
Imitation, nonsymbolic						
Experimental	32.42±3.61	37.68±2.85	38.42±2.19	2.01	−6.00 (−7.94, −4.07)	−6.11 (−8.77, −3.45)*
Control	35.53±3.24	35.94±3.51	35.33±3.93	0.06	.11 (−1.86, 2.08)	
Imitation, intransitive						
Experimental	33.32±5.17	37.63±4.17	38.37±4.15	1.08	−5.05 (−7.46, −2.65)	−5.44 (−8.58, −2.30)*
Control	36.26±3.14	36.17±2.88	35.67±4.33	0.16	.39 (−1.79, 2.57)	
Imitation, transitive						
Experimental	28.74±6.79	35.47±5.33	36.11±4.80	1.25	−7.37 (−10.24, −4.50)	−6.31 (−10.60, −2.02)*
Control	32.79±6.37	33.61±3.71	33.50±7.16	0.10	−1.06 (−4.48, 2.37)	
Pantomime, nonsymbolic						
Experimental	33.74±4.85	36.42±4.72	37.79±2.18	1.08	−4.05 (−6.16, −1.94)	−3.33 (−5.90, −.77)
Control	34.89±5.92	35.72±5.44	35.33±6.39	0.07	−.72 (−2.30, .86)	
Pantomime, intransitive						
Experimental	32.11±7.70	37.05±7.18	38.42±3.42	1.06	−6.32 (−9.11, −3.52)	−6.93 (−10.08, −3.78)*
Control	33.16±5.74	33.22±4.22	32.17±5.42	0.18	.61 (−.98, 2.20)	
Pantomime, transitive						
Experimental	28.47±8.42	35.37±5.73	35.26±4.81	0.99	−6.79 (−9.33, −4.25)	−6.96 (−10.95, −2.96)*
Control	34.05±6.21	34.00±5.43	33.61±7.21	0.07	.17 (−3.15, 3.48)	
Recognition of gestures total						
Experimental	7.74±1.28	9.11±1.24	8.84±1.50	0.79	−1.11 (−1.77, −.45)	−1.44 (−2.27, −.61)*
Control	8.00±1.60	7.78±1.52	7.56±1.54	0.28	.33 (−.21, .87)	
Transitive gestures						
Experimental	4.68±.67	4.68±.58	4.63±.83	0.07	.05 (−.20, .31)	−.23 (−.56, .11)
Control	4.42±.90	4.22±1.17	4.11±1.18	0.30	.28 (.05, .51)	
Intransitive gestures						
Experimental	3.05±1.03	4.42±.84	4.21±.98	1.15	−1.16 (−1.74, −.57)	−1.27 (−2.02, −.52)*
Control	3.58±1.02	3.56±.86	3.39±1.04	0.18	.11 (−.40, .62)	

NOTE. Values are expressed as means ± SD for baseline, 2 months posttreatment, and 2 months follow-up and as mean (95% confidence interval) for within-group (baseline to follow-up) and between-group change scores (at follow-up).

* Significant Group × Time interaction (MANOVA, $P<.05$).

Table 4 Baseline, posttreatment, and follow-up differences and change scores in each group (95% confidence interval) for QOL

Outcome/Group	Baseline	Posttreatment, 8 wk	Follow-up, 8 wk	Cohen's *d*	Within-Group Score Change	Between-Group Score Change
SSQOL-38 total						
Experimental	111.74±31.52	100.42±29.79	98.11±34.06	0.42	13.63 (1.88, 25.39)	12.24 (−2.92, 27.40)*
Control	111.63±25.20	111.78±18.71	111.78±17.75	0.01	1.39 (−8.94, 11.72)	
Physical state						
Experimental	13.63±4.54	11.53±3.81	11.95±4.66	0.37	1.68 (−.18, 3.55)	1.63 (−.79, 4.05)
Control	13.68±4.36	14.11±4.63	13.78±4.56	0.02	.06 (−1.61, 1.72)	
Communication						
Experimental	9.42±3.92	8.58±4.29	8.32±3.85	0.28	1.11 (−.38, 2.59)	2.49 (.52, 4.47)
Control	9.32±3.80	10.17±3.28	11.00±3.60	0.45	−1.39 (−2.80, .02)	
Cognition						
Experimental	7.00±3.09	6.37±3.02	5.58±2.99	0.47	1.42 (.13, 2.71)	1.37 (−.12, 2.85)
Control	4.74±2.13	4.67±1.94	4.72±1.90	0.01	.06 (−.75, .86)	
Emotions						
Experimental	13.63±5.00	12.47±4.65	12.16±5.06	0.29	1.47 (.03, 2.91)	1.86 (−1.08, 4.81)
Control	14.74±4.59	15.44±5.22	15.28±4.31	0.12	−.39 (−3.14, 2.36)	
Feelings						
Experimental	13.26±4.82	12.53±3.84	12.42±4.96	0.17	.84 (−1.13, 2.82)	−.21 (−3.44, 3.01)
Control	15.58±4.39	15.28±4.74	14.78±4.36	0.18	1.06 (−1.68, 3.79)	
ADL						
Experimental	26.79±9.85	23.26±10.30	23.05±11.02	0.36	3.74 (.25, 7.22)	2.51 (−2.18, 7.21)
Control	26.37±8.66	24.28±8.02	25.39±7.79	0.12	1.22 (−2.16, 4.61)	
Sociofamiliar function						
Experimental	28.74±9.31	25.68±8.48	25.32±9.42	0.37	3.42 (.06, 6.79)	2.64 (−.98, 6.27)
Control	27.21±8.09	27.44±6.47	26.83±4.44	0.06	.78 (−.72, 2.27)	

NOTE. Values are expressed as means ± SD for baseline, 2 months post-treatment and 2 months follow-up and as mean (95% confidence interval) for within (baseline to follow-up) and between-group change scores (at follow-up). Significant Group × Time interaction (MANOVA, $P<.05$).

group. This outcome might be owing to the fact that both groups received interventions with limited beneficial effects on ADL function. Previous studies have shown that both restorative and compensatory approaches can improve ADL function in apraxia patients.[5,14,15,17,36-38] Several reviews have been conducted to date on both intervention approaches used in the ULA treatment.[8,13,20,39] The restorative intervention on apraxia has focused on sensory integration, perceptual-motor performance, and selective attention.[39] Few intervention studies have measured the effect of apraxia treatment on ADL functionality. Moreover, the methodological quality of the studies is limited and highly heterogeneous.[21] Smania et al[15] achieved ADL improvements through gesture training by using objects and pantomimes. Goldenberg and Hagmann[36] studied the effectiveness of direct training in grooming, dressing, and eating. However, these authors only found improvements in those specific ADL and, therefore, could not generalize the improvements to other ADL. Goldenberg et al[38] taught patients the structure—function relationships underlying correct performance and compared that approach with direct ADL training. The direct ADL training improved function but no beneficial effects of the experimental training were observed.[38]

The compensatory treatment most commonly used is the strategic training approach implemented by Cantagallo et al,[13] which is based on strategies to teach the patient to complete the activities in an adaptive manner, despite their limitations. Van Heugten et al[17] reported significant ADL improvements by adding learning strategies focused on overcoming apraxic deficits. Recently, Donkervoort et al[5] studied the effect of a strategy training integrated into an OT rehabilitation program. They obtained short-term improvements in ADL functioning.[5] Functional improvements were also reported by Geusgens et al,[40,41] from trained tasks to untrained tasks, during the apraxia strategy training. Our findings are in line with the results obtained by Geusgens et al[40,41] in terms of the generalization of cognitive training improvements in poststroke apraxia but not to achieve transference of these positive changes to general ADL function.

Our results concerning neuropsychological function showed significant improvements for the rehabilitation group in gesture recognition (mean difference, 1.28 points) and gesture production (mean difference, 18.65 points), compared with the control group at follow-up. Smania et al[14] achieved significant improvements in ideational and ideomotor tests, improving the ability to understand and produce transitive and intransitive gestures and decreasing the frequency of praxis errors after rehabilitation. Recently, Stemanova et al[42] assessed a functional recovery evaluation tool and gesture concepts and production in poststroke ULA, obtaining significant improvements.[42] Imitation and pantomimes are compromised in apraxia and share neural processing pathways.[33] Imitation can be performed without action goal or motor memory coming into play, unlike with pantomime (which is elicited verbally [eg, "brush your teeth"]). Thus, pantomime is believed to be the most sensitive test to assess motor memory and action goals.[43] Therefore, rehabilitation treatments should include pantomimes, imitation, and manipulation as specific tools to approach apraxia.

The compensatory approach to neuropsychological function was studied by Van Heughten et al,[17] who reported slight effects on object use and gesture imitation.

Related to QOL, the combined functional rehabilitation showed no improvements. Evidence shows that altered gesture recognition and production might lead to poorer longer-term QOL and community life poststroke.[44] Although ULA is not recognized as a limitation (whereas hemiplegia is), the occupational limitations and loss of social roles due to ULA have a negative effect on QOL[45] and are difficult to recover, as reflected in this study. Moreover, upper extremity functional impairment has been related to decreased QOL.[46] Physical function and social role satisfaction have been described as the domains most affected in QOL. Moreover, even if patients have similar disability levels, QOL depends on other factors, including comorbidities, fatigue, pain, and cognitive symptoms.[47] Therefore, isolated functional rehabilitation would be insufficient to recover poststroke QOL.

Finally, our results showed that the THEP had insufficient effects on ULA recovery. The apraxia approach is complex, and evidence suggests the need for a combination of compensatory, restorative, and psychological strategies, in which patients play an active role.[48-50]

Study limitations

One limitation observed was that the BI is not a stroke-specific outcome tool and, therefore, might not be sensitive enough to detect praxis errors or the characteristic trial-error attempts of apraxia syndrome. Likewise, it does not identify the specific moment at which the error in the activity occurs, but only assesses whether the activity is completed or how much assistance is needed to complete it successfully.

Among the strengths, we can highlight the design and exclusion of participants whose stroke had occurred less than 2 months before to avoid spontaneous improvement or more than 24 months before to avoid chronification and implantation of altered activity patterns.[51] Furthermore, we used an innovative combined intervention and a strong specific evaluation protocol focused on the most influential and highly valued variables by stroke survivors, carers, and clinicians, included in a recent initiative called The Core Outcome Measure in Effectiveness Trials (COMET).[52]

Conclusions

The combined functional rehabilitation protocol produces improvements in neuropsychological function of poststroke ULA patients. However, the isolated application of a THEP does not lead to therapeutic benefit, reinforcing the need to include specific combined protocols for ULA functional rehabilitation. Future studies with larger sample sizes are needed to determine the benefits of these innovative rehabilitation strategies and to analyze their effect on functionality and QOL of poststroke ULA patients.

Suppliers

a. EPIDAT 3.1; Servicio de Epidemiología, Xunta de Galicia.
b. Power Analysis and Sample Size (PASS 13) software; NCSS Statistical Software.
c. SPSS Statistics 20.0; IBM Corp.

Keywords

Activities of daily living; Apraxias; Quality of life; Rehabilitation; Stroke; Upper extremity

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