Toward Improving Poststroke Aphasia: A Pilot Study on the Growing Use of Telerehabilitation for the Continuity of Care

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Background: Aphasia is a quite common and very disabling symptom following stroke, negatively affecting patient's quality of life. Aim of the study is to evaluate the effectiveness of a rehabilitation training for aphasia that employ a touch-screen tablet using a virtual reality rehabilitation system (VRRS-Tablet). *Material and Methods:* Thirty patients with aphasia due to ischemic or hemorrhagic stroke were randomized into either the control or the experimental group and assessed by means of a specific neuropsychological evaluation. The study lasted 6 months and included 2 phases. During the former, the experimental group underwent an experimental linguistic treatment performed using the VRRS-Tablet, while the control group was trained with a traditional linguistic treatment. In the latter, the control groups were delivered to territorial services, while the experimental group was provided with the VRRS-Tablet. *Results:* The experimental group improves in all the investigated areas, except for writing, while the control group only improves in comprehension, depression, and quality of life. *Conclusions:* Our study has demonstrated the effectiveness of a home-based telerehabilitation program specific for poststroke aphasia. The use of telerehabilitation by means of VRRS-Tablet could be one of the best solutions to treat aphasic patients after their discharge, promoting continuity of care by monitoring functional outcomes, maintaining preserved abilities, reducing depression, and improving linguistic functions, besides the psychological well-being.
Key Words: Aphasia—telerehabilitation—virtual reality training—home care

Introduction

Almost 28% of patients affected by both ischemic and hemorrhagic stroke had an aphasic syndrome in the acute stage.[1-3] Aphasia may be fluent (Wernicke's aphasia, transcortical sensory aphasia, conduction aphasia), if patients typically exhibit difficulty with receptive language (i.e., verbal comprehension), or nonfluent (global aphasia, Broca's aphasia, transcortical aphasia motor), if they typically exhibit difficulty with expressive language (i.e., speech production).[4,5] Many patients with aphasia during the 3-4 months following stroke show gradual mechanisms of spontaneous recovery, important to retrieve most of the language skills.[1,6] Aphasia has a significantly negative impact on patients' well-being, independence, social participation, quality of life, and it is often associated with severe depression.[7,8] The treatment of the disorder is multidisciplinary, and it depends on symptoms, location of the brain lesion, etiology, and preserved cognitive and linguistic skills, given that such skills are also positive prognostic factors for the functional recovery.[5,9] An early therapy is important to promote the recovery of speech, crucial for daily communication and social participation, and the global rehabilitation of

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neurological symptoms associated with aphasic disorder.[10] One of the most used traditional rehabilitative techniques is "Speech and Language Therapy,"[9,11]which aims at the treatment of 3 linguistic domains, that is, phonology, lexicon, and syntax, in order to facilitate functional communication.[12] The outcomes of Speech and Language Therapy depend on the amount of weekly practice and the total duration of training.[11] Among the growing field of innovative technologies, virtual reality (VR) systems could be used to monitor, manipulate, and increase the aphasic patient's interaction with their environment aimed at promoting functional recovery.[13] Specifically, VR offers a range of potential benefits for the treatment of aphasia: rich virtual environments, immediate feedback, funny and engaging experience can increase motivation and encourage intensive practice of linguistic function.[14] Indeed, Marshall et al[14] have shown that the use of the language stimulation, by using the Eva Park VR platform, has led to an improvement in functional communication.

In the last few years we have witnessed the development of telemedicine, a set of services whose goal is to promote "home care," through the use of innovative technologies (teleconsultation, remote assistance, and telerehabilitation), in situations where therapist and patient are not in the same locality.[15,16] Moreover, telemedicine overcome the barriers related to access to services caused by distance or difficulty of patient's mobility, potentially reducing the costs of the national healthcare system.[17] Specifically, telerehabilitation for poststroke patients could be a promising intervention for the remote supervision of different forms of therapies aimed at motor, cognitive, and neuropsychiatric improvement.[18] A lot of research have shown that telerehabilitation can decrease long-term disability, increase secondary prevention, and allow follow-up after acute phase of treatment, enhancing the positive responses to therapy and encouraging continuity of care.[19-23] Theodoros et al[24] sustains that telerehabilitation is a model of home service for the treatment of aphasic disorder in addition to the traditional face-to-face treatment. In fact, in the last years, a series of telerehabilitation programs or apps have been developed for poststroke patients with aphasia, which can be used on computers[10,25] or on mobile devices, such as tablets.[26-28] Choi et al developed a telerehabilitation program, "iAphasia," thanks to which it is possible to train patients on 6 linguistic domains that can be modulated according to their deficit.[29] Another telerehabilitation system that has been developed in recent years is the VR rehabilitation system (VRRS), including the Tablet version, which have cognitive and speech-related modules aimed at improving cognitive and linguistic deficits in patients with neurological damage.[30,31]

The aim of this study is to evaluate the effectiveness of a specific rehabilitation training for aphasia, using the VRRS-Tablet. Furthermore, we attempted to evaluate whether and to which extent the use of such tool affects psychological well-being, quality of life, and mood of the patients.

Material and Methods

Study Population

Thirty patients with aphasia due to either ischemic or hemorrhagic stroke (mean ± SD age: 51.2 ± 11.3 years), admitted to the IRCCS Centro Neurolesi "Bonino-Pulejo" of Messina, were enrolled in this study and randomized into either the control (CG: n = 15) or the experimental (EG: n = 15) group. A more detailed description of the 2 groups is in Table 1.

Inclusion criteria were (1) diagnosis of vascular brain injury of either hemorrhagic or ischemic etiology (the latter involving the middle cerebral artery); (2) absence of severe spasticity with an Ashworth Scale less than 3; (3) absence of disabling sensory alterations (i.e., hearing and visual loss), and (4) absence of severe medical and psychiatric illness, according to the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition and International Classification of Diseases-10.

Exclusion criteria were severe paresis of the upper limb (muscle research council < 3); severe cognitive impairment; epileptic seizure nonresponding to treatment.

The local Ethics Committee approved the study and all subjects were informed and gave their written consent to study participation and publication.

Assessment

All patients were assessed by means of neuropsychological evaluation at baseline (T0), after 12 weeks (T1), and at the end of the protocol, 12 weeks later (T2). The patients were administered: Token Test (TT), to detect receptive language disorders in aphasic patients[32];"Esame Neurologico Per l'Afasia" (ENPA), to examine the starting skills in areas relating to naming, comprehension, repetition, reading and writing, calculation[33]; Aphasic Depression Rating Scale (ADRS), to measure depression in patients with aphasia during the subacute stage of stroke[34]; Euro-Qol-5D (EQ-5D), as a measure of health-related quality of life.[35] In order to assess the effects of the device on the functional independence and the psychological well-being, we administered the Psychosocial Impact of Assistive Devices Scale (PIADS) to the EG (for more details see Table 2).[36]

Procedure

The study lasted 6 months and included 2 phases, lasting 12 weeks each. The EG and the CG performed the training 5 days a week, each session lasting about 50 minutes. During the first phase (T0-T1), both groups were hospitalized at our Research Institute, undergoing the same exercises but performed in a different way. The EG patients underwent an experimental linguistic treatment

Table 1. *Demographical description of the sample*

	Experimental	Control	All
Participants	15	15	30
Age	51.1± 10.3	51.4 ± 12.7	51.2 ± 11.3
Education	13.7 ± 2.4	12.8 ± 3.9	13.3 ± 3.2
Gender			
Male	7 (46.7%)	7 (46.7%)	14 (46.7%)
Female	8 (53.3%)	8 (53.3%)	16 (53.3%)
Profession			
Employee	6 (40.0%)	6 (40.0%)	12 (40.0%)
Freelance	4 (26.7%)	5 (33.3%)	9 (30.0%)
Retired	2 (13.3%)	3 (20.0%)	5 (16.7%)
Unemployed	3 (20.0%)	1 (6.7%)	4 (13.3%)
Etiology			
Ischemic	10	9	19
Hemorrhagic	5	6	11
Brain lesion site/side			
Cortical right	6	5	11
Subcortical right	4	5	9
Cortical left	3	3	6
Subcortical left	2	2	4

Continuous variables were expressed as mean ± standard deviation, whereas categorical variables as frequencies and percentages.

Table 2. *Assessment tools*

Test/Scale	Domain	Description
Token Test (TT)	Language	The Token Test[32] is used to evaluate oral comprehension in aphasic subjects. with a series of tokens, of various shapes, colors and sizes with which the subject must perform different tasks. The items consist of 36 verbal orders divided into 6 parts with increasing difficulty, which the subject must perform by operating on tokens. The score ranges from a minimum of 0 to a maximum of 36 points and is given by the sum of the items to which the subject has answered correctly.
Esame Neuropsicologico Per l'Afasia (ENPA)	Language	The E.N.P.A.[33] includes a series of tests that assess the presence, severity and main characteristics of aphasia in the examined subject. it is divided into transcoding tests, naming tests, word lists generation, comprehension tests and tests requiring the use of the number system and calculation.
Aphasic Depression Rating Scale (ADRS)	Depression	The ADRS[34] is a nine-item questionnaire that rates external symptoms of depression such as insomnia, weight loss, outward signs of anxiety, and fatigability. The ADRS is scored by adding item scores into a combined score, with a higher score indicating more depressive symptoms.
EuroQoL-5D (EQ-5D)	Quality Of Life	EQ-5D[35] is a standardized instrument developed as a measure of health-related quality of life. The EQ-5D consists of a descriptive system and the EQ VAS. The descriptive system comprises 5 dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. The EQ VAS records the patient's self-rated health on a vertical visual analogue scale. This can be used as a quantitative measure of health outcome that reflects the patient's own judgement.
Psychosocial Impact of Assistive Devices Scale (PIADS)	Psychosocial	The PIADS[36] is a 26-item, self-report questionnaire to assess the effects of an assistive device on functional independence, well-being, and quality of life. The 3 subscales of the PIADS are Competence, Adaptability and Self-esteem. The first one (12 items) measures feelings of competence and efficacy. The second subscale, Adaptability (6 items), indicates a willingness to try out new things and to take risks. The third subscale, Self-esteem (8 items), indicates feelings of emotional health and happiness. Scores can range from −3 (maximum negative impact) through zero (no perceived impact) to +3 (maximum positive impact).

(ELT) performed using the VRRS. Each exercise of the ELT had a self-advancement of difficulty, to guarantee the best-personalized training. Indeed, reaction time, type, and number of variable stimuli of exercise were set according to patient's abilities and needs (see Table 3). Instead, the participants in the CG were trained with a traditional linguistic treatment with the same exercises as ELT, but using paper-pencil tools. In the second phase (T1-T2), each group followed 2 different paths: the CG was delivered to territorial services, where they undergo conventional speech therapy, while the EG were provided with a touchscreen tablet (VRRS-Tablet). However, both the groups were submitted to the same amount of treatment. The VRRS-Tablet contained the previous protocol of linguistic exercises modulated on the capability of each patient. When the device was given to the EG patients and their caregivers, they were trained to use the instrument and the software. Twice a week the neuropsychologist performed a videoconference with EG patients to monitor the rehabilitation process carried out in their own home and discuss the feasibility and performance of the exercises. The protocol exercises could be performed by the patient both online and offline: in this latter way, the data were recorded by the software and transmitted to our control panel as soon as the tablet went online.

The Telerehabilitation System

VRRS is a tool used in clinical practice for the rehabilitation and telerehabilitation of a wide spectrum of pathologies. Specifically, in literature, there are different studies aimed at demonstrating VRRS validation in motor and cognitive rehabilitation of poststroke patients.[37-39] VRRS allows telerehabilitation, in addition to telemedicine and teleconsulting, with remote territorial and home control. This system integrates different rehabilitation modules (motor, cognitive, linguistic, and orthopedic) and represents a real clinical and technological innovation. The therapist configures the rehabilitation training of each patient in a simple way, establishing the exercises and period of treatment. This allows monitoring the patient remotely in his/her home, reducing the costs of health care and the length of hospital stay. This is achieved by a real-time pc/professionals interaction, comparable to Vis/Vis interaction, adapting the time to the patient's ability with an increase in its compliance. In fact, VRRS is conceived as a "central HUB" to which it is possible to connect, through a USB, a series of specific devices, completely synchronized and integrated with the System. In particular, the VRRS-Tablet is given to the patients to let them do their exercises at home, and it is controlled remotely from a workstation, called Cockpit. The VRRS-Tablet contains about 30 different exercises, with over 1000 customizable and editable levels, divided into cognitive and linguistic modules, which includes exercises on attention, memory, perception, executive functions, and speech/language abilities. The exercises automatically adapt to the patient's performance, thanks to an optimal intensity training for every cognitive condition. In fact, each exercise has a customizable setting efficiency. The VRRS-Tablet is equipped with patient and therapist mode: the former allows performing the exercises and monitoring the data produced, while the latter allows monitoring the patient's progress through the platform. VRRS has 2 main categories of exercises. The first category includes 2D exercises in which the patient interacts with objects and scenarios through the touch screen or a particular magnetic sensor coupled with a button, which emulates mouse interaction. The second one consists of 3D exercises, in which patients interact with 3D virtual scenarios and immersive objects through a magnetic localization sensor generally positioned on the hand (which allows a detection of the final effector's 3D position). In this study, the linguistic module with 2D scenarios was mainly used. The program aimed to rehabilitate the language skills through the naming of figures represented on

Table 3. *VRRS-Tablet linguistic exercise*

Compose the word – acoustic item textual item visual item	Compose the word by using the sequence of letters suggested by acoustic, textual, and visual items
Compose the complex words	Identify visual stimuli, select the number and type of letters needed to write the name and compose the word entirely
Rewrite the word – acoustic item textual item visual item	Rewrite the word suggested by acoustic, textual, and visual items on the screen all the letters used to compose the word are shown
Write the word – acoustic item textual item visual item	Write the word indicated by acoustic, textual and visual items, without further suggestions
Complete the logical relation	Move a colored stick to correctly complete the indicated logical relation
Match the colored stick to the number	Select a colored stick that correspond to the indicated number
Collect the money up to 1, 10, 100, and 1000	Move the presented coins and banknotes in order to collect the amount indicated above

screen and tasks of composition, writing and rewriting suggested by acoustic, textual or visual item (Table 3).

Statistical Analysis

Data were analyzed using the R version 3.4.0 considering $P< .05$ as statistically significant. The χ^2 test was used to compare proportions in categorical variables, whereas the Mann-Whitney *U* test to compare quantitative variables.

ENPA raw scores for all tasks were standardized, and the scores within the same domain (naming, comprehension, writing, calculation, repetition, and reading) were averaged to create a single score to be used in subsequent analyses.

Using the lme4 package of R, we performed a linear mixed effects analysis of the relationship between clinical outcome (measured by TT, ADRS, EQ-5D, ENPA domains) and treatment. Thus, any model included the 2-level variable "treatment" (1 = experimental; 0 = control) and the 3-level variable "evaluation time" (T0, T1, and T2) as fixed effects, the subject's variability as random effect, as well as correlated intercepts and slopes for the fixed factors. We also included an interaction term for treatment and evaluation time. Homoscedasticity was investigated through the Levene test, for both the fixed factors. *P* values were obtained by likelihood ratio tests of the full model, including the effect "treatment" against the model without this effect. The variance of random effects model was used to estimate the R^2 as a standardized measure of effect sizes. As post hoc test, pairwise comparisons of all levels by Student's *t*test were computed on the Least Square Means differences adjusted with the Tukey's test. Finally, the Wilcoxon signed-rank test was used to evaluate changes in PIADS scores from T1 toT2.

Results

No significant differences in age ($P= .88$) and education ($P= .66$) between the 2groups were found. Linear mixed effects analysis results showed that the scores of TT ($X^2(3) = 33.78$; $P < .001$; $R^2 = .92$), ADRS ($X^2(3) = 21.26$; $P < .001$; $R^2 = .92$), and EQ VAS($X^2(3) = 25.98$; $P < .001$; $R^2 = .84$) were affected by the type of the rehabilitative treatment. On the contrary, no effects on EQ-5D score were found ($X^2(3) = 2.20$; $P= .53$; $R^2 = .53$). The post hoc analysis results are reported in Table 4, where estimates expressed in the first column represent the mean changes between groups/times. Although there was no difference between

Table 4. *Post hoc analysis by the Least Square Means differences*

		Estimate	Std. Err.	*t* value	*P* value
Token Test	CG T0-EG T0	1.0	2.35	.44	.67
	CG T0-CG T1	−1.2	.59	1.98	**.02**
	CG T0-CG T2	−2.0	.59	3.37	**<.01**
	EG T0-EG T1	−3.5	.59	5.86	**<.001**
	EG T0-EG T2	−7.3	.59	12.45	**<.001**
	CG T1-EG T1	−1.3	2.35	.54	.60
	CG T1-CG T2	−.8	.59	1.39	.17
	EG T1-EG T2	−3.9	.59	6.59	**<.001**
	CG T2-EG T2	−4.3	2.35	1.84	**.04**
Aphasic Depression Rating Scale	CG T0-EG T0	.6	1.67	.36	.72
	CG T0-CG T1	1.9	.68	2.83	**<.01**
	CG T0-CG T2	2.3	.68	3.32	**<.01**
	EG T0-EG T1	4.1	.68	5.95	**<.001**
	EG T0-EG T2	6.5	.68	9.57	**<.001**
	CG T1-EG T1	2.7	1.67	1.64	.12
	CG T1-CG T2	.3	.68	.49	.63
	EG T1-EG T2	2.5	.68	3.61	**<.001**
	CG T2-EG T2	4.9	1.67	2.92	**<.01**
EuroQol-5D	CG T0-EG T0	−2.7	3.51	.76	.45
	CG T0-CG T1	2.7	1.95	1.37	.18
	CG T0-CG T2	8.7	1.95	4.44	**<.001**
	EG T0-EG T1	11.3	1.95	5.81	**<.001**
	EG T0-EG T2	22.0	1.95	11.28	**<.001**
	CG T1-EG T1	6.0	3.51	1.71	.10
	CG T1-CG T2	6.0	1.95	3.08	**<.01**
	EG T1-EG T2	10.7	1.95	5.47	**<.001**
	CG T2-EG T2	10.7	3.51	3.04	**<.01**

Significant differences are in bold.

Abbreviations: CG, control group; EG, experimental group; T0, evaluation at T0; T1, evaluation at T1; T2, evaluation at T2.

scores of the 2 groups at baseline, at the end of the study there was a significant difference in all test scores. Indeed, the EG scores improved during the whole study, differently from those of the CG which significantly improved only from T0 to T1 (i.e., TT and ADRS) or from T1 to T2 (i.e., EQ-5D).

Neuropsychological Examination for Aphasia

Linear mixed effects analysis results showed that the type of the rehabilitative treatment affected comprehension ($X^2(3) = 18.14$; $P < .001$; $R^2 = .92$), repetition ($X^2(3) = 16.77$; $P < .001$; $R^2 = .94$), reading ($X^2(3) = 28.23$; $P < .001$; $R^2 = .91$), naming ($X^2(3) = 15.22$; $P < .01$; $R^2 = .98$), and calculation ($X^2(3) = 37.77$; $P < .001$; $R^2 = .98$) domains. On the contrary, the group did not affect significantly the writing domain ($X^2(3) = 4.93$; $P = .18$; $R^2 = .91$).

Post hoc analysis results (Table 5) showed significant differences between EG and CG only at T2, concerning reading ($P = .046$) and calculation ($P = .049$). As shown in Figure 1, the EG improved throughout the duration of the study, differently from the CG that significantly improved only from T0 to T1 in all language aspects, but for repetition and calculation. Indeed, for repetition we observed a significant improvement in both groups, whereas for calculation we found an improvement only in the EG (Table 5).

Impact of the Device on Functional Independence and Quality of Life

A significant difference ($P < .01$) between T1 and the end of the study was found for all dimensions of PIADS (Competence, Adaptability, Self-esteem).

Discussion

Our study has demonstrated the effectiveness of a home-based telerehabilitation program for poststroke aphasia, provided by means of a touch-screen tablet that uses a VR system (i.e., the VRRS-Tablet). Indeed, this home training influenced positively the recovery of the linguistic functions, mood, and perception of one's state of health. The telerehabilitation is an application of information and communication technologies for the remote support of rehabilitation services.[40] As demonstrated by Turolla et al, thanks to this method, it is possible to promote the continuity of care over time (after discharge) and in space (from the hospital to the patient's home), also increasing frequency and intensity of rehabilitative therapy.[30] There is growing evidence that continuity of care is one of the strengths of treatment through tele-rehabilitation programs and our data confirm this hypothesis.[23] In fact, we observed how the CG has a slight improvement during the treatment carried out at our center, but there is no further linguistic progress when they were delivered to local services. On the contrary, the EG showed a progressive and continuous improvement during the 6 months of the study protocol, highlighting the potential effectiveness of specific treatments based on technological and innovative device, such as the VRRS-Tablet, in the recovery and maintenance of linguistic functions. We believe that VRRS-Tablet have led to better results thanks to the use of VR, that encourages active exploration, improves engagement, and provides motivation and fun, allowing longer training sessions and improving adherence to treatment. Furthermore, it provides patients with knowledge of the results and performance, enhancing neuroplasticity and motor learning.

Table 5. *Post hoc analysis results on ENPA dimensions*

	Comprehension		Repetition		Reading		Naming		Calculation	
	Test value	*P*value	Test value	*P* value	Test value	*P* value	Test value	*P* value	Test value	*P* value
CG T0-EG T0	.23	.82	.17	.87	.16	.87	.02	.98	.23	.82
CG T0-CG T1	3.90	**<.001**	4.82	**<.001**	3.64	**<.001**	2.69	**<.01**	1.08	.28
CG T0 − CG T2	4.39	**<.001**	9.04	**<.001**	2.73	**.01**	3.93	**<.001**	1.01	.32
EG T0-EG T1	7.71	**<.001**	8.20	**<.001**	5.39	**<.001**	5.13	**<.001**	4.45	**<.001**
EG T0-EG T2	8.60	**<.001**	14.45	**<.001**	8.38	**<.001**	.81	.43	10.59	**<.001**
CG T1-EG T1	1.49	.15	1.20	.25	.65	.52	.47	.65	.88	.39
CG T1-CG T2	1.48	.14	4.22	**<.001**	.19	.85	1.24	.22	.07	.94
EG T1-EG T2	2.83	**<.01**	6.25	**<.001**	5.12	**<.001**	4.44	**<.001**	6.14	**<.001**
CG T2-EG T2	1.90	.07	1.82	.09	2.16	**.046**	1.11	.28	2.09	**.049**

Significant differences are in bold.
Abbreviations: CG, control group; EG, experimental group; T0, evaluation at T0; T1, evaluation at T1; T2, evaluation at T2.

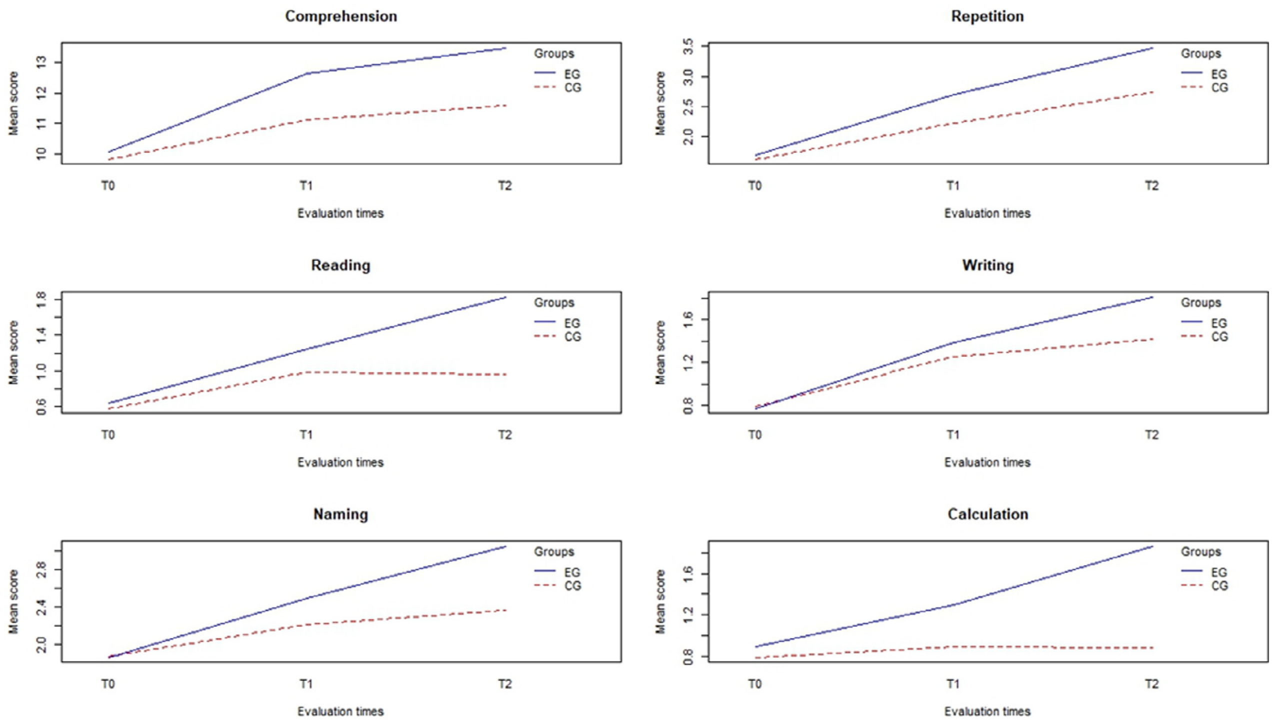

Figure 1. *This figure shows the improvement of the experimental group in comparison to the control one. Notably, patients undergoing the experimental training presented with a better improvement, persisting throughout the all study duration.*

Thus, we may argue that the use of telerehabilitation using VR for aphasia is feasible and effective, given that it allows to potentiate the rehabilitation process (from hospital to patient's home), increasing the recovery of language skills, besides cognitive functions.[27] This evidence is further supported by PIADS' results, which have shown that EG consider the VRRS-Tablet as a device with a good impact on quality of life. Recently, for the rehabilitation of poststroke patients with aphasia, several telerehabilitation programs have been developed to be easily used at their own home.[26,27,29,41] Among these, the "iAphasia" by Choi et al, which seems to be an effective and flexible telerehabilitation's method.[29] This tool is similar to VRRS-Tablet in that both are able to stimulate the same linguistic domains; however, VRRS allows increased feedback, thanks to the use of 2D/3D VR, further promoting motor and language recovery.[37] In line with previous studies, our findings showed that the EG obtain an improvement in all the investigated linguistic domains, such as comprehension, naming, reading, repetition, and calculation. The aphasia has a negative impact on the patient's psychological well-being, independence, quality of life, and mood,[7,8] interfering with daily communication and social participation.[10] In particular, some studies have shown how treatment through a telerehabilitation program could have positive effects on mood, especially on depression.[8,42-44] According to these findings, we have observed how in the EG there was a reduction of the depressive state at the end of the telerehabilitation treatment. Concerning the quality of life in stroke patients (another important variable we have investigated), literature shows conflicting data. In fact, Linder had underlined the improvement in quality of life following the execution of a telerehabilitation program,[8] while Forducey and Mayo have not found differences between experimental and control group in such items.[45,46] Our results show that there is no significant effect of experimental treatment on quality of life (EQ-5D) in EG, although there is an improvement in perception of one's own health (EQ VAS). To this end, we believe that the patients were not very satisfied by the improvements obtained, as they expected a nearly complete recovery of language abilities after the training. Considering that the recovery was partial, the perception of their quality of life has been negatively influenced.

The main limitation of our study is the small simple size, which is maybe not adequate to demonstrate the real efficacy of this telerehabilitation program for aphasic patients. Thus, further larger sample studies should be fostered to confirm these promising findings, also evaluating the cost/effectiveness ratio of telerehabilitation, besides caregiver burden.

In conclusion, this study shows that the application of telerehabilitation programs could be one of the solutions to treat poststroke aphasic patients after their discharge. In fact, the VRRS-Tablet could be a promising treatment (also monitoring the outcomes) to maintain and/or potentiate language abilities, reduce disability, and promote psychological well-being.

Declaration of Interest

The authors report no conflict of interest.

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