Effectiveness of the Home-Based Graded Repetitive Arm Supplementary Program Combined with Occupational Therapy Versus Conventional Occupational Therapy Alone on Quality of Life and Upper Limb Function After Stroke: A Randomized Controlled Trial

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State of art

Stroke is a sudden injury that transiently or permanently impairs certain brain functions depending on the affected area. Depending on the location and extent of the lesion, individuals may experience a range of impairments, including motor, cognitive, or perceptual deficits[1]. Among sensorimotor impairments, loss of upper limb functionality on the affected side is one of the greatest rehabilitation challenges. At least 80% of people who suffer a stroke experience some form of impairment in their upper limb, while only 15% achieve significant functional recovery. Since our arms and hands are essential for performing many activities of daily living (ADLs), any functional limitation can lead to loss of independence in these tasks, potentially resulting in disability[2].

Recent studies have shown that the rehabilitation time dedicated to the upper limb is insufficient[3]. Increasing the intensity of therapy compared to standard rehabilitation can improve outcomes, especially in the chronic phase[4]. To increase intensity, strategies include longer therapy sessions and promoting a higher number of repetitions to support motor learning and the generalization of acquired skills. Technological advancements—such as robotics and virtual reality—are used to intensify home-based rehabilitation, ensuring patient follow-up and enabling a high volume of practice. However, these technologies often imply additional costs for patients or neurorehabilitation centers, which can hinder implementation[5]. In some cases, due to their complexity or the digital divide among older adults, acquiring or adhering to such treatments may be difficult. A practical solution to this challenge is to incorporate home-based exercises to extend rehabilitation time while minimizing economic barriers[6]. Over the years, home exercise approaches have evolved from unsupervised routines and written instructions to technology-assisted programs.

The Home Graded Repetitive Arm Supplementary Program (Home-GRASP)[7] is a home-based exercise program supervised by an occupational therapist. It was developed by a neurorehabilitation team at the University of British Columbia in Canada (https://neurorehab.med.ubc.ca/grasp/). The program consists of a booklet with 33 exercises targeting various aspects of upper limb rehabilitation, including stretching, strengthening of the arm and hand, coordination, and fine motor skills.

The program adopts an individualized approach where the patient, either independently or with the assistance of a caregiver, performs a set of exercises prescribed by the occupational therapist. Prior to implementation, the therapist conducts an in-person session at the rehabilitation center to explain each exercise thoroughly and address any questions. During this session, the patient also receives all the materials needed to carry out the program at home. To ensure proper follow-up, patients are asked to maintain a daily activity log, recording the number of sets and repetitions performed for each exercise, perceived difficulty, and any relevant observations. These logs allow for detailed monitoring and are reviewed weekly by the occupational therapist, who evaluates progress and adjusts the program as needed. In addition to reviewing the logs, the therapist collects verbal feedback during weekly follow-up sessions to address questions or difficulties with exercise execution. As part of the ongoing monitoring process, a Visual Analogue Scale (VAS) is used to assess the presence of pain in the affected arm or hand. Based on the information gathered, the therapist may increase or decrease the intensity or difficulty of the exercises—for example, by increasing the number of repetitions, using objects that are harder to manipulate, or introducing heavier weights. The HomeGRASP program is designed to be performed for 1 hour per day, 7 days a week, over a total period of 8 weeks. This program offers several advantages over previously proposed options. It adds seven additional hours of upper limb rehabilitation per week, supervised by a healthcare professional, and incorporates task-oriented training and strengthening exercises—approaches that promote a high number of repetitions and have demonstrated effectiveness in upper limb rehabilitation. Finally, it stands out for its ease of use, free and open access to the exercise manual available on the University of British Columbia's website (https://neurorehab.med.ubc.ca/grasp/), and the fact that the materials required to carry out the program are easily obtainable, without the need to purchase them from specialized medical supply stores.

To date, 19 studies have been conducted on the GRASP program[9-27]. A qualitative study explored the experience of carrying out the GRASP program in hospitalized patients during the first weeks after suffering a stroke[9]. Other studies have been conducted in the chronic phase after stroke, while participants were receiving outpatient treatment, or after completing their formal rehabilitation and continuing the program exclusively at home[10-11]. Among them, there is only one multicenter study comparing the GRASP program with a control group that only received information about stroke rehabilitation and general health. These studies conclude that using the GRASP program improves upper limb functionality and use after a

stroke[13]. One study combined GRASP with transcranial magnetic stimulation[13], comparing it with a control group that performed only GRASP. Both groups showed improvements in the functionality of the affected upper limb, but no significant differences were found between the groups at the end of the intervention. However, at a one-month follow-up, the group that received GRASP in combination with transcranial magnetic stimulation did show significant differences compared to the GRASP-only group. A comparative study was also conducted with constraint-induced movement therapy (CIMT)[14] in patients in the acute phase after stroke. Both approaches require a minimum level of prior mobility in the affected arm and hand to be applied appropriately. In this study, the group that performed the GRASP program showed significantly better improvements than the CIMT group.

One study compared the use of home-based rehabilitation software through tablets versus GRASP[15]. The tablet-based device showed greater improvements in both cognitive and sensorimotor recovery of the affected upper limb. However, in that study, the GRASP group only performed the program 30 minutes per day (instead of the recommended 1 hour) and 3–4 days per week (instead of 7 days per week).

Another study compared the GRASP program with a home-based virtual reality program[16], but no statistically significant differences were found. One study added software for detecting compensatory upper limb movements using Kinect, providing real-time feedback to the patient during home-based execution of the program, allowing for immediate correction of compensations[17].

Four studies have proposed future comparative trials with GRASP. The first explores the combination of transcranial electrical stimulation with GRASP versus GRASP alone[18]. Another compares a lower limb exercise program (PREP) versus PREP combined with GRASP[19]. A third proposes a home-based music therapy program versus GRASP[20]. The fourth will compare a Chinese calligraphy program with GRASP[21]. Results of these four studies have not yet been published.

The program's inclusion in community settings[22] has been explored, along with the possibility of remote follow-up via video calls or phone calls[23-24], showing good adherence among participants through telematic monitoring.

Surveys have been conducted with occupational therapists in Vancouver[25] and the UK[26] to assess their knowledge of GRASP and its use in daily practice. These studies show that only 22% of surveyed therapists were familiar with the GRASP program and 36% had never heard of it. Finally, in 2023, a bibliometric study was conducted to assess the impact and use of the GRASP program in the rehabilitation process, identifying a total of 15 publications available up to that year[27].

To date, no trial has compared conventional treatment combined with the GRASP program versus conventional treatment alone. Based on the above, the implementation of the program in Spain is proposed, aiming to assess changes in perceived quality of life and upper limb functionality as primary outcomes. Additionally, manipulative skills, upper limb use in activities of daily living (ADLs), and personal autonomy will be evaluated as secondary outcomes. All of this will be carried out through the HomeGRASP program as a complement to conventional occupational therapy rehabilitation.

General Objective: To evaluate changes in quality of life and motor function in stroke patients participating in the HomeGRASP home-based rehabilitation program combined with conventional occupational therapy, compared to standard conventional occupational therapy treatment.

Specific Objectives:

1) To assess improvement in the motor function of the affected upper limb in the intervention group using the Wolf Motor Function Test (WMFT), in comparison with the control group.
2) To measure changes in perceived quality of life in both groups using the CAVIDACE scale, in order to identify differences in emotional, social, and physical well-being.
3) To analyze the type of exercises performed and the time dedicated to home rehabilitation in the intervention group.
4) To evaluate adherence to the HomeGRASP home rehabilitation program and the intensity of physical activity using accelerometry, comparing the intervention and control groups.
5) To compare performance in gross motor tasks of the affected upper limb using the Box and Block Test (BBT), to assess improvements in unimanual dexterity.
6) To assess unimanual and bimanual dexterity through the Purdue Pegboard Test (PPT), analyzing improvements in coordination and manual skills between both groups.
7) To measure the quantity and quality of use of the affected upper limb during daily activities using the Motor Activity Log-30 (MAL), to determine whether the HomeGRASP program enhances participation and use of the affected limb compared between groups.
8) To evaluate changes in difficulty performing activities of daily living (ADLs) in both groups using the Duruöz Index (DI).

9) To assess functional independence in both groups using the Functional Independence Measure (FIM), to determine whether the experimental program contributes to greater independence in everyday tasks.
10) To assess the impact of pain in both groups using the Visual Analog Scale (VAS), to determine whether the HomeGRASP program helps reduce pain associated with rehabilitation activities.
11) To describe treatment adherence in the HomeGRASP group, and to identify barriers and facilitators to participation in the program.

Methodology

Study Design: This will be a single-blind, parallel-group randomized clinical trial, in which participants will be randomly assigned to one of two groups: an intervention group or a control group.

- **Control group:** This group will only receive conventional occupational therapy treatment at the rehabilitation center. The standard treatment will typically consist of 2–3 sessions per week, each lasting 45 minutes. The approaches used during the sessions will be based on mobilisation of the affected upper limb only if necessary (maximum 10 minutes of the session), task-oriented training and ADL training.
- **Experimental group:** will carry out the conventional treatment previously described in the control group together with the HomeGRASP programme at home. This programme has a duration of one hour of exercises at home, seven days a week, over a period of eight weeks. As the programme involves supervision by the occupational therapist of the exercises performed at home, 20-30 minutes of the conventional session will be devoted to reviewing this plan. Prior to the start of the programme, an explanatory session will be held with the patient and, if necessary, with the caregiver to show and teach the correct performance of the exercises proposed in the programme, as well as the delivery of the material necessary to carry them out.

Randomisation: Participants will be randomised after receiving detailed information about the study, signing the informed consent form, and completing the baseline assessment. To ensure comparability between groups and reduce the risk of allocation imbalance, a block randomisation method with a 1:1 allocation ratio will be used, employing blocks of 6 participants. The randomisation will be performed using the *blockrand* package in the R statistical software. This procedure will be carried out

by an independent researcher who will not be involved in the assessments or interventions, ensuring the impartiality of the process.

Blinding: The study will be single-blinded to the evaluator who will be a person outside the group allocation. To minimise systematic bias due to non-blinding, participants will be instructed not to inform the evaluators of the group assignment they received. Likewise, prior to data analysis, the thesis supervisor will carry out a reassignment of codes so that the PhD student does not know the group in which the person participated.

Study population and sample: The study population includes patients who have suffered a stroke who are treated as outpatients in neurological rehabilitation centres. The study population will be all persons who have suffered a stroke who meet the following inclusion and exclusion criteria.

Inclusion criteria:

- Being of legal age.
- Having suffered only one stroke event and being clinically stable.
- At least 3 months after the stroke and less than 12 months.
- Signed informed consent.
- Be able to report any harmful effects (e.g. shoulder pain).
- Be able to follow instructions and perform the exercises independently for one hour. If unable to do so, be assisted by a caregiver to ensure completion of the exercises.
- Perform at least 10º of active wrist or finger extension.
- Ability to lift the scapula of the affected upper limb against gravity.

Exclusion criteria:

- Having other neurological conditions other than stroke.
- Excessive pain in the affected upper limb that prevents him/her from correctly performing the exercises proposed in the programme. Visual Analogue Scale (VAS > 7).
- Visual perception deficit that prevents him/her from correctly performing the exercises proposed in the programme.
- Excessive muscle tone (spasticity or hypertonia) that prevents him/her from correctly performing the exercises proposed in the programme. Asworth > 2.
- A Folstein Mini Mental State Examination (MMSE) score ≥22 is required.

The study sample will be selected from Hermanas Hospitalarias neurological rehabilitation centres from among people attending outpatient treatment who meet the inclusion criteria and who do not present conditions that would lead to exclusion.

In the event that it is necessary to recruit more participants to reach the sample size, other neurorehabilitation centres in the Valencian Community will be contacted.

Sample size estimation will be based on preliminary data from the first 24 participants included in the study. For each outcome variable, the pre-post difference by group will be calculated, and the effect size will be estimated using Cohen's d. The required sample size per group will then be determined using a two-sided t-test with a significance level of 0.05 and 80% power, adjusting for an expected attrition rate derived from the proportion of missing post-intervention data observed in this initial subsample. This calculation will be performed using the R statistical software and the pwr package.

Evaluation tools:

- Primary outcomes:
    - Wolf Motor Function Test (WMFT)[28] quantifies upper limb (UM) motor ability through timed and functional tasks. The tool consists of 17 items including 6 items involve timed functional tasks, items 7 and 14 are measures of strength, and the remaining 9 items consist of analysing the quality of movement when completing various tasks.
    - CAVIDACE[29]: is an assessment of the perceived quality of life of adults with brain injury from the perspective of an external evaluator. It is recorded by a person who knows the user well (e.g. professionals, relatives, legal guardians...). The sections included in this tool are: emotional well-being, interpersonal relationships, material well-being, personal development, physical well-being, self-determination, social inclusion and rights.

- Secondary outcomes
- Box and Blocks Test (BBT)[30]: is an assessment tool that measures the person's unimanual gross motor skills. It consists of carrying the maximum number of wooden blocks from one side of the box to the other for 1 minute.
- Purdue Pegboard Test (PPT)[31]: is a test that aims to measure unimanual and bimanual finger dexterity, gross hand and arm movement in patients with upper limb impairments resulting from neurological and musculoskeletal conditions. It consists of a board with two parallel rows with 25 holes in which different metal pins, washers and tubes are placed, which are located in the upper part of the board in four cavities. It has four parts: the first assesses dexterity of the dominant hand, the second with the non-dominant hand, the

third assesses simultaneous bimanual coordination and the last measures alternating bimanual coordination by means of an assembly task.

- Motor Activity Log-30 (MAL)[32]: consists of a 30-item questionnaire which subjectively assesses the amount of use and quality of use of the affected upper limb after a stroke during the performance of different tasks of daily living. The score for each item ranges from 0 (no use of the affected arm to perform the activity) to 5 (includes the affected hand as before the stroke).

- Duruöz Index (ID)[33], also called the Cochin Scale, contains 18 questions and is a self-administered scale that measures the difficulty in performing ADLs of cooking, dressing, personal hygiene, office tasks, etc. Patients rate their dexterity from 0 (no difficulty) to 5 (impossible to perform).

- Functional Independence Scale (FIM)[34]: is an 18-item global measure of disability. Each item has seven ordinal levels of scores from 1 (total assistance) to 7 (total autonomy) in order to quantify the functional independence of the person assessed.
- Visual Analogue Scale (EVA)[35]: this is a scale to assess the impact or current amount of pain the patient has. It is based on a 10-centimetre line with both ends clearly delimited, differentiating at one end the score 0 'no pain', and at the other end the score 10 'the greatest pain possible or that I have ever felt'. The patient has to mark exactly the point along this line. Once it has been marked, it is measured with a tape measure and the measurement obtained is the assigned pain score..

Other variables to be collected in the study:

Sociodemographic data: sex, date of birth, mother tongue, level of studies completed, type of home and cohabitation situation, presence of caregiver (if yes, it is also collected whether it is formal or informal care and the hours per week), previous and current job, degree of disability and/or recognised dependency.

Clinical data: diagnosis, date of diagnosis, aetiology and location of the injury, time of evolution, dominance, most affected upper limb, pharmacological treatment, time of admission to the current rehabilitation unit, time of rehabilitation since the stroke, other diagnoses and the presence of sensory, motor, cognitive or behavioural sequelae.

Health and lifestyle: height and weight, smoking, drug and/or alcohol consumption.

Data on the implementation of the HomeGRASP programme: completed programme, days on which the exercises were not carried out, time spent during the session correcting the activities, modifications made during the programme, notes suggested by the participants during the programme.

Accelerometry: The GeneActiv accelerometer (GENEActiv, ActivInsights Ltd, Kimbolton, United Kingdom, https://activinsights.com/digital-health-technologies/professional-wearables/geneactiv/) will be used in both the intervention and control groups to assess adherence to the rehabilitation program and the intensity of physical activity performed during the study. This device will be worn on the wrist of the affected limb and will continuously measure acceleration across three axes, providing data on the duration, frequency, and intensity of daily physical activity. Participants in both groups will wear the accelerometer for the 8-week intervention period, allowing for comparison not only of adherence to the HomeGRASP program in the experimental group, but also of overall physical activity in the control group. The data will be downloaded weekly during occupational therapy sessions and processed at the end of the data collection period using R packages specifically designed for this purpose, such as **GGIR**.

Procedure:

The clinical staff of the occupational therapy areas of the centres that will participate in the trial will receive an informative session about the project. These professionals will be in charge of inviting the users of the centre who meet the inclusion and exclusion criteria to participate in the study and will be in charge of explaining the project in detail and collecting the informed consent.

When the patient is included in the study, he/she will be assessed by a blinded assessor from an external resource, with no prior or subsequent contact with the patient, only to carry out the pre- and post-intervention assessments. This evaluator will collect both the variables from the assessment tools and the rest of the study variables (socio-demographic, clinical and health and lifestyle data). Once assessed, a randomisation process will be carried out in which the patient will be assigned to the experimental group or the control group.

Once assigned to one of the two groups, the intervention phase will begin. Both groups will carry out their intervention within 8 weeks. During this period both groups will continue their conventional occupational therapy treatment, generally between

2-3 sessions per week of 45 minutes each, at the rehabilitation centre based on: mobilisation of the neurological upper limb if necessary (maximum 10 minutes), task-oriented training and training in ADLs. Depending on the assigned group, in addition to the conventional treatment, the experimental group will perform the HomeGRASP programme. The control group will only perform the conventional treatment.
Bearing in mind that, after a brain injury, it is very common to experience pain in the shoulder of the more affected arm, this programme includes exercises specifically designed to address such issues. However, if the exercises are not performed correctly, there is a risk that shoulder pain may develop or worsen if already present. Since the programme is supervised weekly by an occupational therapist, the Visual Analogue Scale (VAS) will be used during each follow-up session to monitor pain levels and assess their impact on programme adherence. It is not uncommon for some discomfort to arise during the initial weeks, but with proper supervision and timely adjustments to the exercises, this pain typically resolves within a short period and becomes mild or disappears entirely. Additionally, participants often report a noticeable reduction in pain sensations upon completion of the programme.

If during the follow-up of the patient, regardless of the week of the intervention, the patient reports shoulder pain during the performance of any movement or during any specific exercise, this will be modified in a way that the therapist considers more appropriate (e.g. fewer repetitions, less range of motion, less weight load...) in order to allow the person to perform the exercise without excessive pain (VAS =<6). Just as the modification of the activities can be changed weekly to add more difficulty to the exercise, if necessary, it can also be varied as often as necessary to adjust to the user's capacity for movement and correct execution. If, despite the modification of these exercises, the pain on the VAS scale is greater than 7 for two weeks in a row, the patient will be withdrawn from the study in order to avoid possible complications and/or increased pain.

At the end of the eight weeks, a post-intervention re-evaluation will be carried out by the external evaluator and the results obtained will be analysed.

Analysis Plan

All analyses will be conducted using R software version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria; http://www.r-project.org). A two-sided significance level of 0.05 will be considered statistically significant.

To assess the normality of continuous variables, the Kolmogorov-Smirnov test with Lilliefors correction will be applied. Quantitative variables will be described using means and standard deviations or medians and interquartile ranges, depending on

their distribution. Categorical variables will be reported as absolute and relative frequencies (n, %).

To compare baseline sociodemographic, lifestyle, or clinical characteristics between intervention groups, the Student's t-test or Mann-Whitney U test will be used for continuous variables with parametric or non-parametric distributions, respectively, and the chi-square test for categorical variables.

To assess within-group changes before and after the intervention, paired Student's t-tests or Wilcoxon signed-rank tests will be applied depending on the normality of the data. Between-group comparisons of pre-post changes will be analysed using the independent Student's t-test or Mann-Whitney U test, as appropriate. In all comparisons, effect sizes will be estimated using **Cohen's d** for parametric data or **Cliff's delta** as a non-parametric alternative, in order to quantify the magnitude of the observed differences.

To evaluate changes in functionality and quality of life, as well as secondary outcomes, between intervention groups while adjusting for potential confounders, multiple linear regression models will be used. Baseline values of the outcome variables will be included as covariates to reduce regression to the mean. Confounder selection will be based on a thorough literature review. Variables with a p-value < 0.20 in bivariate analysis and that modify the estimated effect by more than 10% after adjustment will be included in the final model. If missing data are found in confounding variables (<15%), multiple imputation methods will be considered.

Data analysis will be conducted using both intention-to-treat (ITT) and per-protocol (PP) approaches. The ITT analysis will include all participants as originally allocated at randomisation, regardless of treatment adherence or completion. For ITT, linear mixed-effects models will be applied. This approach is especially relevant considering that some participants may drop out due to pain or other reasons, offering a realistic assessment of the intervention's impact in clinical practice.

The per-protocol analysis will include only those participants who strictly followed the study protocol. This analysis will exclude participants who withdrew, did not adhere to the treatment, or switched groups, providing an estimate of the treatment effect under optimal adherence conditions.