

EFFECT OF MIRROR THERAPY VERSUS COGNITIVE THERAPEUTIC EXERCISE ON UPPER LIMB FUNCTIONALITY; FUNCTIONAL INDEPENDENCE; AND POST-STROKE QUALITY OF LIFE. RANDOMISED TRIAL. (Author's final version – Accepted Manuscript)

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Running title: Mirror therapy versus cognitive therapeutic exercise in stroke

REFERENCE:

Fernández-Solana, J., Vélez-Santamaría, R., Moreno-Villanueva, A., Álvarez-Pardo, S., González-Bernal, J., Santamaría-Peláez, M., & González-Santos, J. (2025). Effect of Mirror Therapy Versus Cognitive Therapeutic Exercise on Upper Limb Functionality, Autonomy, and Poststroke Quality of Life: A Randomized Trial. *The American Journal of Occupational Therapy*, 79(5), 7905205150.

<https://doi.org/10.5014/ajot.2025.050834>

Abstract

Importance: The combination of rehabilitation techniques may be useful to optimize an individualized treatment and efficient resource utilization. **Objective:** To assess the effectiveness of the combination of Cognitive Therapeutic Exercise and Mirror Therapy with Task-Oriented Training on upper limb functionality, fine and gross motor skills; the use of the paretic arm; functional independence in activities of daily living, and quality of life in subacute stroke. **Design:** Randomized trial, longitudinal and multicenter study. One control group (CG) and two experimental groups (EG). Assessment before, after, and three months post-treatment. **Setting:** University of Burgos and Burgos University Hospital. **Participants:** Consecutive non-probabilistic sampling. 120 patients with subacute stroke and motor symptoms in the upper limb. Those with tremor due to another neurological disease and/or cognitive impairment were excluded. **Intervention:** Mirror Therapy + Task-Oriented Training to EG1 and Cognitive Therapeutic Exercise + Task-Oriented Training to EG2 over 20 sessions of one hour. The CG received their usual therapy prescribed by the rehabilitation physician and that simulates everyday situations. **Outcomes and Measures:** The studied variables were evaluated with the Action Research Arm Test, Box and Blocks Test, Motor Activity Log, Functional Independence Measure-Functional Assessment Measure and Stroke-Specific Quality of Life Scale. **Results:** Statistically significant differences were found between the CG group and both EG, with improvement in upper limb functionality, fine and gross motor skills; the use of the paretic arm; functional independence in activities of daily living, and quality of life. No differences were found between the EGs. **Conclusions and Relevance:** The application of these combinations improved all the variables studied. **What this article adds:** The use of these therapies may improve upper limb functionality, fine and gross

motor skills; the use of the paretic arm; functional independence in activities of daily living, and quality of life.

Keywords: stroke; mirror therapy; cognitive therapeutic exercise; task-oriented therapy; upper limb; functionality; quality of life.

1. Introduction

Stroke is currently a significant public health and quality of life (QoL) issue (Oolabi et al., 2022). According to the World Stroke Organization (WSO), there are 12.2 million new strokes each year, with 80% of individuals experiencing various sequelae afterward. Therefore, addressing these sequelae is fundamental for improving QoL (Feigin et al., 2022).

These sequelae, which significantly affect the upper limbs, can result in an impairment of function in the upper limbs, affecting fine and gross motor skills, and the ability to perform activities of daily living (ADL:(Poltawski et al., 2016). Another important sequela that can be observed is "learned non-use" (Marquardt et al., 2017) In this case, the individual avoids using the affected upper limb due to motor difficulties even though they have some residual functional capability. Functional independence is also affected, directly impacting QoL (Sivan et al., 2011).

Implementing a comprehensive rehabilitation approach to address the various stroke sequelae is essential for optimal recovery. Additionally, personalized treatment tailored to the unique needs of each individual is crucial (EBRSR. (s.f.), n.d.). Achieving this requires an emphasis on pre- and post-treatment assessments to objectively measure outcomes using specific assessment tools (Colomer et al., 2023; Fernández-Concepción et al., 2008; Fernández-Solana et al., 2022; Furuta et al., 2022; H. C. Hsieh et al., 2021;

Santamaría-Peláez et al., 2022). In rehabilitation, evidence-based therapies are crucial to ensure that the treatments applied are effective and supported by scientific research (Langhorne et al., 2011). Examples of such therapies include Mirror Therapy (MT), Cognitive Therapeutic Exercise (CTE), and Task-Oriented Training (TOT) (Díaz Castro & Rodríguez López, 2019a; (EBRSR. (s.f.), n.d.); K. E. Lee et al., 2022; Lisalde-Rodríguez & García-Fernández, 2016).

MT employs visual illusions to enhance motor function. This therapy utilizes a mirror to create an illusion of normalcy in the affected limb (Muñoz-Gómez et al., 2023). The mirror reflects the unaffected limb while the affected one remains hidden behind it. By moving the healthy limb, its reflection creates the appearance of movement in the affected limb, tricking the brain into perceiving normal movement, which has been shown to be effective in various studies to improve motor function and neuroplasticity in patients with stroke (Kundi & Spence, 2023; Nogueira et al., 2021; Seyyah & Topuz, 2023).

CTE, also known as the Perfetti method, is a neurorehabilitation approach that provides personalized and specific treatment for each patient. Its goal is to recover lost or altered movement and involves assigning the patient the task of solving a specific problem that can be addressed through fragmented movement of body segments, assisted by the therapist (Díaz Castro & Rodríguez López, 2019b; Parra Horta, 2018; Serrat et al., 2021).

In this case, for example, a patient performs fragmented upper limb movement tasks with the therapist's assistance, identifying the positioning of their upper limb in space in relation to nearby objects identified in advance. This technique has demonstrated improvements at cognitive and motor level in patients with hemiplegia according to the review by Vaca Garces & Figueredo Villa (2023), as well as Domínguez-Ferraz et al. (2014) in their systematic review of the recovery of motor and functional capacity in patients with sequelae derived from a stroke.

On the other hand, TOT represents an effective method for developing motor skills and brain plasticity through the repetition of specific and practical tasks that simulate everyday actions (Almhdawi et al., 2016; Alsubiheen et al., 2022; Preissner, 2010). Almhdawi et al. (2016) demonstrated significant and clinically meaningful functional improvements measured by the Motor Activity Log (MAL-30) (Santamaría-Peláez et al., 2022), Canadian Occupational Performance Measure (Yang et al., 2017) and Wolf Motor Function Test (Pometti et al., 2025), after six weeks of clinical upper limb functional training for three hours per week. The results of Alsubiheen et al. (2022) indicate that an eight-week task-oriented ADL training improves upper limb functions and gross manual dexterity.

Finally, it is important to emphasize that in rehabilitation, prioritizing the optimization of functional recovery by balancing factors such as time, resources, and the effectiveness of interventions is essential. Combining therapies that have been proven effective can significantly enhance treatment effectiveness. Recent research demonstrated that combining these therapies activates neuroplasticity more effectively than applying them separately (Bayón-Calatayud et al., 2014; Cano-de-la-Cuerda et al., 2015). For example, Bai et al (2019) combined conventional therapy (physiotherapy focusing on motor function and ambulation, and occupational therapy of upper limb functional training and ADL training) with movement-based MT and task-based MT; which target different motor functions; both MT were found to be effective in improving function, with movement-based MT showing superior results. In a double-blind randomised controlled trial involving 30 patients with hemiparesis, progressive reach-to-grasp training combined with trunk restraint for arm recovery in the experimental group resulted in greater functional improvements one-month post-intervention compared to the control group, which received progressive reach-to-grasp training without trunk restraint

(Michaelsen et al., 2006). This highlights the importance of combining interventions that address multiple aspects of motor function to achieve optimal rehabilitation outcomes.

As a hypothesis, the combination of MT + TOT or CTE + TOT was expected to be more effective in improving upper limb function after a stroke compared to isolated TOT therapy. However, up to the current date, no study has directly compared this combination of techniques, highlighting the necessity for further research. Therefore, this study aimed to assess the effectiveness of combining these techniques on overall motor function of the affected upper limb, fine and gross motor skills, the use of the affected arm, functional independence in ADL and QoL, in stroke patients.

2. Method

2.1. Participants

A multicenter longitudinal study conducted in collaboration with the University Hospital of Burgos (HUBU), San Juan de Dios Hospital (Burgos), Reina Sofía Hospital (Córdoba), and the University of Burgos (Spain) involved 120 stroke patients.

Inclusion criteria for study participants were as follows: (1) subacute phase of stroke, defined as the period from symptom onset to hospital discharge, with less than 3 months elapsed since symptom onset (Mah et al., 2022), (2) residual hemiparesis diagnosed due to ischemic or haemorrhagic stroke, (3) mobility in the affected upper limb within stages II and IV of the Brunnstrom scale (Waghavkar & Ganvir, 2015), (4) Montreal Cognitive Assessment (MoCA) (Gomez-Moreno et al., 2021; Ramírez-Moreno et al., 2019) score equal to or greater than 26, (5) aged 18 years or older, and (6) signed informed consent.

Exclusion criteria were: (1) visual deficit or homonymous hemianopsia, (2) Wernicke or mixed aphasia, (3) hemineglect and (4) cognitive deficit (MOCA score less than 26).

The research plan received approval from the Institutional Review Board Approval Committee of HUBU (2134/2019). Data collection was conducted at participating centers by designated personnel, and the data were anonymized before being shared with the research team, maintaining anonymity and confidentiality thereafter. The trial was registered on ClinicalTrials.gov under trial number NCT04163666 (Effects of home-based mirror therapy and cognitive therapeutic exercise on the improvement of the upper extremity functions in patients with severe hemiparesis after a stroke: a protocol for a pilot randomised clinical trial).

2.2. Procedure

Participants in this study were selected upon discharge from the Stroke Unit and the Neurology Service using a consecutive selection method. The sample size was calculated using Power G, concluding that it should consist of 81 stroke participants.

The study design was a randomized, controlled, single-blind clinical trial with three groups: a control group (CG) and two experimental groups (EG). Experimental group 1 (EG1) received MT+TOT, and experimental group 2 (EG2) received CTE+TOT. Our researchers did not conduct any experimental therapy in the control group (CG), they only received TOT treatment (5 days a week) as usual. The evaluators conducting the assessments were blinded to the study conditions.

The study was conducted during the outpatient rehabilitation of the participants. The participants did not receive any intervention prior to the start of the study. Participants were recruited by the rehabilitation physician of each participating centre, who initially assessed whether they met the study's inclusion criteria.

After the initial selection based solely on the presence of upper limb impairment following a stroke, a second selection was carried out applying the study's inclusion and exclusion criteria during the participants' initial assessment. This assessment occurred one month after the stroke event. Participants were then randomly assigned to groups through a masking process in a 1:1:1 ratio. The randomization was centrally generated by an independent investigator using Epidat 4.2, an open-access software for epidemiological analysis that facilitates random allocation, before participant inclusion.

Different researchers administered therapies in the EG. The professionals responsible for implementing the therapies in the various centers were occupational therapists specialized and trained in the techniques used. During the intervention, which spanned over 20 sessions conducted 5 days a week (Luo et al., 2020; Pérez-Cruzado et al., 2017; Saavedra-García et al., 2021), the groups were divided so that participants in EG1 received MT combined with TOT, while participants in EG2 received CTE combined with TOT. Therapies were structured in segments, with 30 minutes allocated to MT or CTE, and the remaining 30 minutes to TOT. However, the CG did not receive any experimental therapy apart from TOT (60 minutes). Therefore, all three groups followed TOT that is their usual therapy prescribed by the rehabilitation physician. The experimental therapies were administered by occupational therapists in the aforementioned hospitals.

After completing the experimental treatment in both experimental groups, a second assessment was conducted using the same battery of evaluation tools as in the initial assessment. In the control group, this second assessment occurred one month after the first assessment, consistent across all three groups. Additionally, a third assessment was conducted for all three groups three months after the second assessment. Figure 1 below shows a flowchart summarizing the procedure.

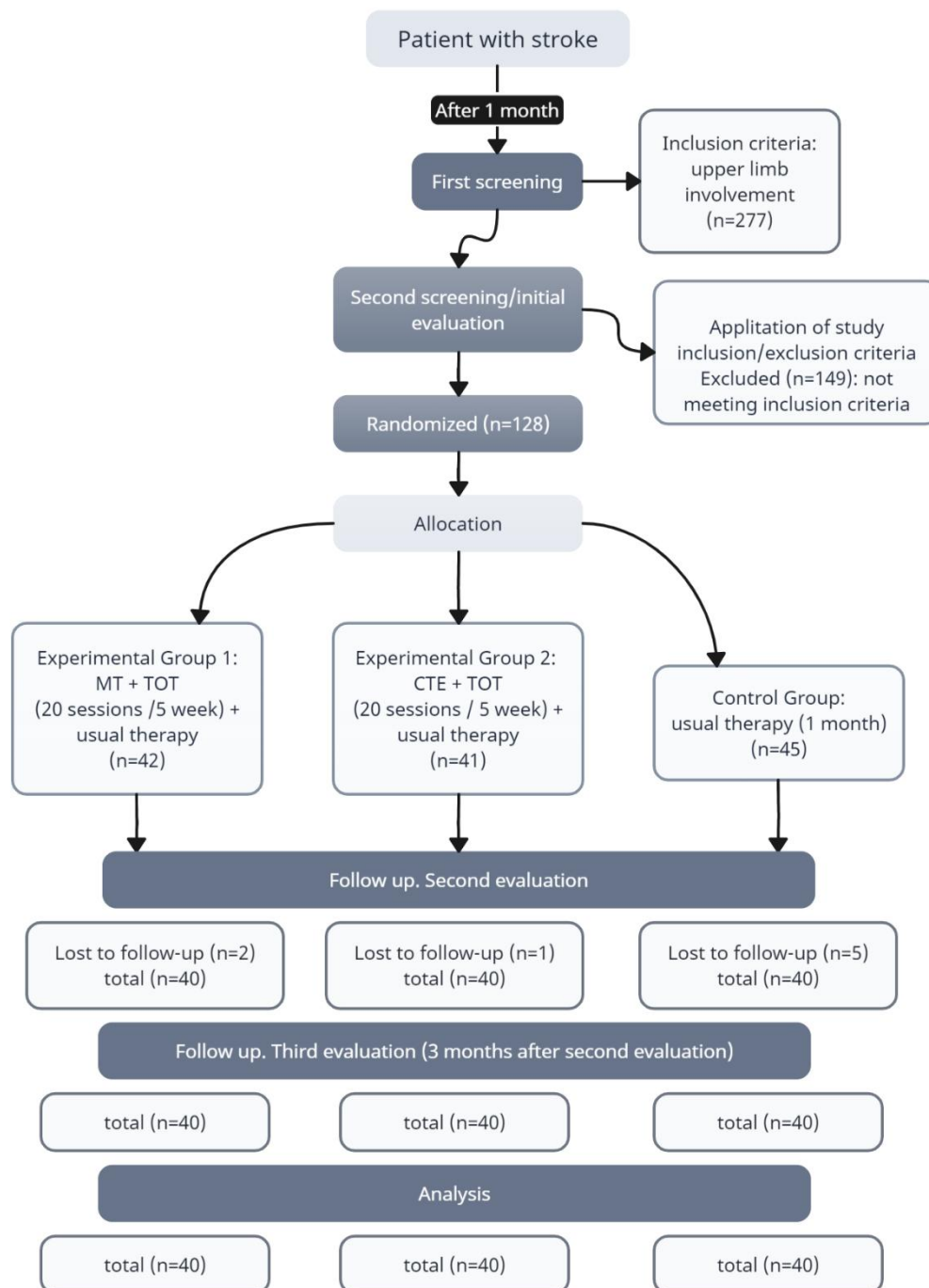


Figure 1. Flowchart of the study

2.3 Instruments

Sociodemographic data such as age and sex; and post-stroke clinical variables such as affected side, dominant side and type of stroke were collected to describe the sample.

Supplementary material 1 shows the relationship between the instruments or scales used for measurement in this study and the variables measured by each of them.

To measure the functionality of upper limb, fine motor skills and gross motor skills of the hand, the Action Research Arm Test (ARAT; (Fernández-Solana et al., 2022) and The Box and Blocks Test (BBT; (Angelos Nomikos et al. 2018) were used. The ARAT is a measure translated and validated in the Spanish stroke population ($\alpha=0.96$), with a good test-retest reliability of 0.78. It comprises 19 items divided into 4 subscales (grasp, grip, pinch, and gross movement), with scores ranging from 0 (unable to complete the task) to 3 (normal performance) on an ordinal scale. Total scores range from 0 to 57 (Pike et al., 2018). This scale is recognized as appropriate, valid, and sensitive for assessing individuals who have experienced a stroke (Lang et al., 2006; Pike et al., 2018).

The BBT (Chen et al., 2019; Desrosiers et al., 1994; Y. W. Hsieh et al., 2020) requires moving 150 wooden blocks within one minute from one compartment to another within a divided box, first using the unaffected upper limb and then the affected one. The score is determined by manually counting the number of blocks moved. It has high test-retest reliability with intraclass correlation coefficients ranging from 0.89 to 0.97.

Quantity and quality of use of the affected arm is measured using the MAL-30 (Santamaría-Peláez et al., 2022) . This tool evaluates how much and how well individuals use their affected upper limb in ADL and instrumental activities of daily living (IADL) following a stroke. The tool used at the clinical level is administered by the practitioner. It consists of 30 items in each of the quantity and quality subscales. Scores range from 0 (the affected arm is never used for the activity) to 5 (the affected arm is able to perform the activity at the same level as before the stroke). A higher score indicates better movement quality and more normalized use of the affected upper limb (Arlette

Doussoulin et al., 2013; Sada et al., 2021; Taub et al., 2011; J. H. Van Der Lee et al., 2004). This instrument has been translated and validated for use in the Spanish-speaking stroke population ($\alpha=0.990$ for the quantity subscale, $\alpha=0.991$ for the quality subscale), also has a test-retest reliability of more than 0.86. (Uswatte et al. 2005).

Functional independence in ADL is assessed using the Functional Independence Measure- Functional Assessment Measure (FIM-FAM; (Law et al., 2008; Martínez-Martín et al., 2009; Nayar et al., 2016; Turner-Stokes & Siegert, 2013). This global disability measure comprises 18 items from the FIM and an additional 12 items from the FAM. Each item is scored on a scale from 1 (total dependence) to 7 (total independence), yielding a total score ranging from 30 to 210. The FIM-FAM demonstrates high internal consistency ($\alpha=0.94$), inter-rater reliability is also excellent, with correlations above 0.990 in all domains of the subscales (Colomer et al. 2023).

And finally, QoL was assessed using the Stroke-Specific Quality of Life (SS-QoL; (Ramírez & Alvarez, 2008) questionnaire, specifically designed for evaluating the QoL in stroke patients. The Spanish version of this questionnaire has been validated and shown to be reliable and practical. It consists of 38 items grouped into 8 domains: physical function, communication, cognition, emotions, social role, ADL, IADL, and social/family role. Additionally, there are two questions about sexual function and employment status. Responses are rated on a scale from 1 (no difficulty) to 5 (extreme difficulty), with total scores ranging from 38 to 190. Lower scores indicate better quality of life for the patient. The SS-QoL scale (Fernández-Concepción et al., 2008) has demonstrated strong psychometric properties with $\alpha=0.95$, and a good test-retest stability with interclass correlation and coefficient 0.89-0.98 (Ramírez Pérez et al. 2005).

2.4 Intervention

2.4.1 Mirror Therapy

For Mirror Therapy (MT), the patient sat in a chair with their forearms placed on a table, and a mirror was placed between both arms at a right angle to the torso. The affected limb was positioned behind the mirror, out of the patient's field of view. The healthy limb was adjusted to be correctly reflected (see Suppl. 2).

MT was executed through three different modes. In the first mode, the patient attempted to replicate the movement of the healthy hand synchronously with the affected hand. In the second mode, the patient imagined themselves performing the mirrored movement of the healthy hand with the affected hand. In the third mode, the therapist assisted the patient's affected hand in imitating the movement of the healthy hand. Progression was individually tailored based on the patient's recovery.

There are studies that show that MT not only improves the function of the affected limb during the specific training task but can also have a positive impact on other everyday activities. For example, a study showed that MT can induce brain changes in the motor area, leading to generalized functional improvement in the use of the affected limb (Ramachandran & Altschuler, 2009). Additionally, another study found that patients who participated in MT not only improved in the direct therapy tasks but also experienced improvements in untrained activities, such as grasping and manual dexterity (Wen et al., 2022). This suggests that the effects of the intervention may extend beyond the specific activities worked on during treatment.

2.4.2 Cognitive Therapeutic Exercise

Cognitive Therapeutic Exercise (CTE) was structured in three progressive levels-primary, secondary and tertiary-that guide the therapeutic process through perceptual-motor tasks of increasing complexity. Each level focused on specific aspects of movement control,

from the management of spasticity to the automation of voluntary motor patterns. Initially, all patients participated in primary-level exercises to acquire proficiency in managing the stretch reflex. Once this proficiency was achieved, they advanced to secondary-level exercises. Later, tertiary-level exercises were introduced, focusing on modifying movements based on perceptual hypotheses, with the aim of automating the control of secondary-level abnormal motor behaviours.

At the primary level, the focus was on addressing spasticity, with the therapist guiding movements alongside the patient. In the secondary level, abnormal irradiation (involuntary activation of muscle groups not directly related to a specific action, due to alterations in the regulation of the central nervous system) was addressed, and patients performed movements with minimal assistance from the therapist. At the tertiary level, emphasis was placed on controlling voluntary movements, aiming to achieve complete automation of movements without therapeutic assistance.

Studies indicate that the benefits gained through CTE extend beyond the exercises directly targeted during therapy. For instance, it has been found that CTE significantly improved motor skills not only in the exercises practiced but also in daily functional tasks. The changes achieved at the tertiary level, where movements were automated, contributed to the patient's greater independence in real-world situations (Diaz Castro & Rodriguez Lopez, 2019c). This suggests that the effects of CTE go beyond the specific tasks, promoting improvements in broader, untrained activities.

2.4.3 Task-oriented Therapy

TOT was structured sequentially, adapting in each session to simulate everyday situations such as ADL (eating, dressing, toileting), IADL (making food, washing clothes, handling money, etc.), work or leisure. Complex activities were divided into simpler tasks to

facilitate learning. For example, when performing the feeding ADL, the task was divided into simple steps in which shoulder flexion, forearm pronation, wrist deviation and different types of grips (cylindrical grip, palmar grip, interphalangeal grip, subterminal grip, etc) were worked on independently. These exercises were carried out with different materials and in progressive degrees of difficulty, increasing the joint range, weight, task speed or accuracy of each simple task and then combining them before performing the complex task. Brief rest periods were interspersed, and the difficulty of the tasks was gradually increased to enhance performance.

Research suggests that the benefits of TOT extend to functional improvements in various activities beyond those directly practiced in therapy. For instance, a study demonstrated that patients who underwent task-oriented training showed significant improvements in ADL and IADL that were not explicitly trained during sessions. The structured, progressive nature of the training helped individuals adapt to and perform complex tasks in their daily lives, thereby enhancing their overall functional independence (Choi & Kang, 2015). This suggests that the effects of TOT can transfer to real-life activities, promoting broader functional gains.

2.5 Statistical Analysis

Descriptive analyses of sample characteristics were conducted, presenting categorical variables in absolute frequencies and percentages, and continuous variables in means and standard deviations (SD). The normality of the dataset was assessed using the Kolmogorov-Smirnov test (Macía Soler & Moncho Vasallo, 2021).

To analyze differences between groups regarding the various assessments conducted during the intervention, analysis of covariance (ANCOVA) was employed. In this analysis, the treatment group to which participants belonged was considered a fixed

factor, while the differential scores of the evaluated variables served as dependent variables, and the initial values of these same variables were used as covariates.

To quantify the effectiveness of the interventions carried out, the effect size for each variable has been detailed using partial eta square (η^2_p) according to the values established by Cohen (1988), where a small effect is indicated when $\eta^2_p < .059$, a medium effect when $\eta^2_p \geq .059$ and a large effect when $\eta^2_p \geq .138$.

Statistical analysis was performed using IBM SPSS Statistics version 28 (IBM Inc., Chicago, IL, USA). A significance level of $p < 0.05$ was considered indicative of statistical significance.

3. Results

The data were collected from 120 patients one month after experiencing a stroke. Table 1 presents the sociodemographic and clinical variables collected, describing the study sample. It should be noted that at baseline there were no statistically significant differences between groups. All groups started on an equal level before the intervention.

Table 1. Sociodemographic and Clinical Data

Variables		n=120	%
Sex	Male	70	58.3
	Female	50	41.7
Age (years)		68.92 $\pm$ 11.79	
Affected side	Left	62	51.7
	Right	58	48.3
Dominant hand	Left	5	4.2
	Right	115	95.8
Affected-dominant hand	Yes	56	46.7
	No	64	53.3

Type of stroke	Ischemic	111	92.5
	Hemorrhagic	8	6.7
Treatment	CG	40	33.3
	CTE	40	33.3
	MT	40	33.3

In Table 2, between the first and second evaluations, statistically significant differences are shown in the functionality, as well as the gross and fine motor skills of (a) the affected upper limb measured with the ARAT, (b) the quantity and quality of use of the affected upper limb, (c) level of functional independence in ADL, and (d) the QoL. Significant differences were observed between the scores of the CG and the two EG in all evaluated variables, but not between the two EGs.

Statistically significant differences between groups were obtained in the ARAT ($F(2,116)= 13.513$. $p<0.001$; $\eta^2p= 0.189$) and BBT ($F(2,116)= 10.741$. $p<0.001$; $\eta^2p= 0.156$), the quantity and quality MAL-30 scale ($F(2,116)= 9.850$. $p<0.001$; $\eta^2p= 0.254$ and $F(2,116)= 6.143$. $p=0.003$; $\eta^2p= 0.096$), FIM-FAM ($F(2,116)= 5.288$. $p=0.006$; $\eta^2p= 0.084$), and SS-QoL ($F(2,116)= 7.331$. $p<0.001$; $\eta^2p= 0.112$).

345 **Table 2.** ANCOVA analysis between the treatment group and the first-second evaluation.

Variables	Group	First evaluation	Second evalua-	Treatment	Mean dif-	SD	P	95% CI		Effect	Observed
		mean (SD)	tion mean (SD)					LI	LS		
ARAT	CG	38.13 (22.129)	35.58 (24.552)	CTE	-10.537	2.738	<.001**	-15.960	-5.114	.189	.998
				MT	-13.613	2.735	<.001**	-19.029	-8.197		
	CTE	29.15 (20.482)	38.45 (19.833)	MT	-3.076	2.694	.256	-8.413	2.260		
	MT	29.50 (18.902)	41.83 (18.940)								
BBT	CG	25.08 (24.091)	26.50 (24.496)	CTE	-5.473	2.050	.009*	-9.533	-1.412	.156	.989
				MT	-9.380	2.030	<.001**	-13.401	-5.359		
	CTE	16.80 (14.141)	23.93 (15.562)	MT	-3.907	2.021	.056	-7.910	.095		
	MT	19.80 (15.955)	30.75 (19.454)								
MAL-30 quantity scale	CG	2.39 (2.173)	2.51 (2.221)	CTE	-.471	.264	.077	-.995	.052	.111	.930
				MT	-1.001	.263	<.001**	-1.523	-.480		
	CTE	1.92 (1.955)	2.64 (1.479)	MT	-.530	.264	.047*	-1.052	-.008		
	MT	2.19 (2.012)	3.37 (1.845)								

MAL-30 quality scale	CG	2.33 (2.149)	2.52 (2.270)	CTE	-.378	.261	.151	-.895	0.140	.096	.882
				MT	-.906	.260	<.001**	-1.421	-.391		
	CTE	1.75 (1.753)	2.46 (1.466)	MT	-.529	.260	.044*	-1.043	-.015		
	MT	1.99 (1.911)	3.16 (1.788)								
FIM-FAM	CG	135.60 (63.501)	141.00 (61.624)	CTE	-4.530	4.287	.293	-13.020	3.960	.084	.827
				MT	-13.558	4.262	.002*	-21.999	-5.118		
	CTE	156.70 (33.636)	167.88 (28.886)	MT	-9.028	4.215	.034*	-17.377	-.679		
	MT	152.73 (35.814)	169.65 (27.023)								
SS-QoL	CG	105.53 (37.989)	100.58 (37.043)	CTE	1.618	3.411	.636	-5.138	8.375	.112	.993
				MT	11.957	3.386	<.001**	5.251	18.663		
	CTE	96.03 (26.105)	90.88 (28.987)	MT	10.338	3.406	.003*	3.593	17.084		
	MT	104.48 (30.573)	93.06 (31.292)								

ARAT: Action Research Arm Test; BBT: Box and Blocks Test; MAL-30: Motor Activity Log; FIM-FAM: Functional Independence Measure-Functional Assessment Measure; SS-QoL: Stroke-Specific Quality of Life Scale; CG: Control Group; CTE: Cognitive Therapeutic Exercise; MT: Mirror Therapy. * p<0.05; **p<0.001

In Table 3, between the first and second evaluations, statistically significant differences were observed for the functionality, as well as gross and fine motor skills of (a) the affected upper limb measured with ARAT and BBT, (b) the quantity and quality of use of the affected upper limb, and (c) QoL. However, no statistically significant differences were observed in functional independence in ADL. Significant differences were also observed between the scores of the CG and the two EG in all significant variables mentioned, but not between the EGs. Statistically significant differences were obtained for ARAT ($F(2.116) = 8.138$, $p < 0.001$; $\eta^2 p = 0.123$) and BBT ($F(2.116) = 11.987$, $p < 0.001$; $\eta^2 p = 0.171$), the quantity and quality MAL-30 scale ($F(2.116) = 7.978$, $p < 0.001$; $\eta^2 p = 0.121$ and $F(2.116) = 8.958$, $p < 0.001$; $\eta^2 p = 0.134$), and SS-QoL ($F(2.116) = 10.244$, $p < 0.001$; $\eta^2 p = 0.150$). However, no statistically significant differences were observed in the BBT ($F(2.116) = 1.674$, $p = 0.197$; $\eta^2 p = 0.058$), nor for FIM-FAM ($F(2.116) = 2.088$, $p = 0.129$; $\eta^2 p = 0.035$).

360 **Table 3.** Analysis of Covariance (ANCOVA) between the treatment group and the first-third evaluation

Variables	Group	First evaluation	Third evaluation	Treatment group	Mean difference	SD	P	95% CI		Effect size	Observed power
		mean (SD)	mean (SD)					LI	LS		
ARAT	CG	38.13 (22.129)	36.75 (24.330)	CTE	-10.067	2.827	<.001**	-15.667	-4.467	.171	.994
				MT	-13.315	2.824	<.001**	-18.908	-7.722		
	CTE	29.15 (20.482)	39.08 (21.007)	MT	-3.248	2.782	.245	-8.759	2.263		
	MT	29.50 (18.902)	42.63 (19.228)								
BBT	CG	25.08 (24.091)	29.08 (24.986)	CTE	-12.165	3.144	<.001**	-18.393	-5.938	.123	.955
				MT	-9.199	3.113	.004*	-15.365	-3.033		
	CTE	16.80 (14.141)	34.30 (16.857)	MT	2.966	3.099	.341	-3.172	9.104		
	MT	19.80 (15.955)	33.86 (19.705)								
MAL-30 quantity scale	CG	2.39 (2.173)	2.73 (2.327)	CTE	-.690	.267	.011*	-1.219	-.160	.121	.951
				MT	-1.047	.266	<.001**	-1.575	-.520		
	CTE	1.92 (1.955)	3.08 (1.605)	MT	-.358	.267	.182	-.886	.170		
	MT	2.19 (2.012)	3.64 (1.637)								

MAL-30 quality scale	CG	2.33 (2.149)	2.61 (2.274)	CTE	-.698	.259	.008*	-1.211	-.185	.134	.970
				MT	-1.076	.258	<.001**	-1.586	-.566		
	CTE	1.75 (1.753)	2.87 (1.612)	MT	-.378	.257	.144	-.887	.132		
	MT	1.99 (1.911)	3.43 (1.606)								
FIM-FAM	CG	135.60 (63.501)	152.55 (55.492)	CTE	-1.522	3.683	.680	-8.817	5.773	.035	.422
				MT	5.510	3.662	.135	-1.742	12.763		
	CTE	156.70 (33.636)	176.13 (26.296)	CG	1.522	3.683	.680	-5.773	8.817		
				MT	7.032	3.622	.055	-.142	14.206		
	MT	152.73 (35.814)	172.45 (26.345)								
SS-QoL	CG	105.53 (37.989)	85.18 (37.332)	CTE	-20.768	5.173	<.001**	-31.014	-10.523	.150	.985
				MT	-19.570	5.135	<.001**	-29.739	-9.400		
	CTE	96.03 (26.105)	82.98 (27.945)	MT	1.199	5.165	.817	-9.030	11.428		
	MT	104.48 (30.573)	84.00 (27.133)								

ARAT: Action Research Arm Test; BBT: Box and Blocks Test; MAL-30: Motor Activity Log; FIM-FAM: Functional Independence Measure-Functional Assessment Measure; SS-QoL: Stroke-Specific Quality of Life Scale; CG: Control Group; CTE: Cognitive Therapeutic Exercise; MT: Mirror Therapy. * p<0.05; **p<0.001

No statistically significant differences were found between the second and third assessments carried out in any of the variables analysed. This means that the long-term results were maintained for the interventions carried out on the patients.

4. Discussion

The results demonstrate a significant improvement in scores following the application of complementary treatment between the first and second evaluation, as well as in the long term. This indicates that both EGs(i.e., the group that performed MT+TOT and the one that carried out CTE+TOT) showed greater improvement in all the variables analyzed.

Statistically significant differences were observed for the functionality, as well as the fine and gross motor skills of (a) the affected upper limb measured with the ARAT and BBT scales, (b) the quantity of use of the affected upper limb, and (c) QoL.. Other studies employing the same assessment instruments also suggest that intervention with MT is beneficial for improving motor functionality of the right upper limb (Carayol et al., 2019; Damsbo et al., 2020; Koevoets et al., 2022). Additionally, it activates mirror neurons when observing, imagining, or attempting to execute movements (Van Vulpén et al., 2016).

Although no previous studies that use the same combination of therapies used here have been found; our research provides evidence that rehabilitation through the combination of techniques leads to improvements in motor performance in patients who have suffered a stroke. This finding is supported by other research (Kim y Shim, 2015; Lim et al., 2016; Mirela Cristina et al., 2015; Park et al., 2015).

Furthermore, QoL in the EG is higher than in the CG. These results were consistent with other studies indicating that the implementation of MT and CTE treatment improves QoL

(Damsbo et al., 2020), and that various forms of intervention significantly enhance QoL (Alsubiheen et al., 2022; Oberlin et al., 2017; Ren et al., 2022). Statistically significant differences were also observed for the variables of quality of use of the affected upper limb ($p=0.003$) and the level of functional independence in ADL ($p=0.006$). Previous studies have shown that specific rehabilitation interventions improve motor capacity and functionality (Carayol et al., 2019; Damsbo et al., 2020; Koevoets et al., 2022; Van Vulpen et al., 2016).

Similarly, statistically significant differences were observed between the two EG and the CG, indicating superior improvement in both EGs compared to the CG. However, no statistically significant differences were found between the two EG. Therefore, it appears that undergoing rehabilitation through the combination of techniques aimed at restoring mobility and functionality of the affected limb, regardless of its nature, is more effective than implementing a more conventional program (Oberlin et al., 2017; Ren et al., 2022; Van Vulpen et al., 2016).

Moreover, significant differences were observed in the quantity and quality of use of the affected upper limb, which is supported by other studies indicating that after a stroke, many patients continue to use their affected upper limb in ADLs, achieving normal performance (Lundquist et al., 2022).

The study has certain limitations that warrant consideration. First, the small sample size suggests that expanding it would enhance its representativeness and statistical power. Second, regarding the inclusion and exclusion criteria, potential adjustments could involve broadening the age range or allowing participants with milder cognitive impairments, as these factors could increase the pool of eligible participants while still

maintaining the study's integrity. Third, the study commenced before the pandemic, which impacted recruitment efforts over an extended period.

Some future research directions include long-term follow-up of patients to assess outcomes over an extended period. Additionally, integrating interventions with other therapeutic methods could be explored. Lastly, exploring emotional variables such as anxiety, depression, and motivation could be valuable in future research, as these factors often influence recovery and patient engagement in rehabilitation.

5. Implications for Occupational Therapy Practice

Occupational therapy plays a crucial role in the functional recovery and enhancement of QoL for stroke patients. However, there remains incomplete evidence concerning many rehabilitation techniques and their optimal combination. The occupational therapy study presented here introduces an additional tool for rehabilitation, demonstrating various patient benefits, including improved hand functionality, fine and gross motor skills of the hand, level of functional independence in ADL, and QoL through a combination of therapeutic techniques.

Implications for clinical practice:

- Improve fine and gross motor skills of the upper extremity, including precision, grip, grasp, and strength: The data obtained from the evaluations (ARAT and BBT) show significant improvements in precision, strength, grip, and grasp. These advancements support the inclusion of specific and gradual tasks tailored to the individual needs of the patient, promoting functional recovery.

- Increase patients' functional independence in their ADLs and IADLs: The improvement in MAL-30 and FIM-FAM scores reflects an enhanced ability of patients to perform daily and instrumental activities independently. This suggests that the integration of specific techniques, such as task simulations in TOT, is essential to regain practical and functional skills.
- Enhance patients' QoL: The increase in SS-QoL scores highlights that these interventions have a positive impact not only on physical function but also on emotional, social, and cognitive well-being. This underscores the need to adopt comprehensive rehabilitation approaches that address multiple dimensions of post-stroke recovery.

6. Conclusions

The results of this study demonstrate that the combination of MT or CTE with TOT is effective in improving the functionality of the affected upper limb, fine and gross motor skills, functional independence in ADL and IADL, as well as the QoL of patients in the subacute phase after a stroke. In the evaluations conducted after the intervention and in the long term (three months), both EG showed significant improvements in all measured variables compared to the CG, with no significant differences between the EG. This suggests that both combinations are equally valid strategies for post-stroke rehabilitation.

It is also concluded that both techniques produce positive outcomes in improving the studied variables, with no significant differences between them. Therefore, both combinations represent viable options for promoting functional recovery in the subacute phase of stroke patients.

These findings are particularly relevant for occupational therapists, as they provide empirical evidence supporting the use of these combined techniques in clinical practice. The integration of these interventions allows for personalized treatments tailored to the specific needs of each patient, optimizing their functionality and quality of life. Additionally, it facilitates the implementation of evidence-based strategies that promote neuroplasticity and recovery of the affected upper limb. Furthermore, the findings enable occupational therapists to adopt a comprehensive approach addressing the physical, emotional, and social dimensions of post-stroke recovery.

Author Contributions

Conceptualization. J.F.-S. and M.S.-P.; methodology. J.J.G.-B. and J.G.-S.; software. J.F.-S. and M.S.-P.; validation. J.F.-S. and M.S.-P.; formal analysis. S.A.-P. and A.M.-V.; investigation. J.F.-S., J.G.-S. and R.V.-S.; resources. S.A.-P. and R.V.-S.; data curation. J.F.-S.; writing—original draft preparation. S.A.-P., A.M.-V. and R.V.-S.; writing—review and editing. S.A.-P., A.M.-V. and R.V.-S.; visualization. J.F.-S. and J.J.G.-B.; supervision. M.S.-P. and J.G.-S.; project administration. J.J.G.-B. and J.G.-S. All authors have read and agreed to the published version of the manuscript.

Funding

This project was funded by Fundació Bancaria Caixa D. Estalvis I Pensions de Barcelona, La Caixa. Reference: CAIXA-UBU002.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University Hospital of Burgos (HUBU 2134/2019, 25 June 2019).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Supplementary material 1. Relationship between the instruments or scales used for measurement in this study and the variables measured

Instruments	Variables
ARAT and BBT	Functionality of upper limb, fine motor skills and gross motor skills of the hand
MAL-30	Quantity and quality of use of the affected arm
FIM-FAM	Functional independence
SS-QoL	Quality of life

ARAT: Action Research Arm Test; BBT: Box and Blocks Test; MAL-30: Motor Activity Log; FIM-FAM: Functional Independence Measure-Functional Assessment Measure; SS-QoL: Stroke-Specific Quality of Life

Supplementary material 2. Example of patient positioning for Mirror Therapy

