



RESEARCH ARTICLE

Effect of concise arm rehabilitation for stroke patients approach vs modified constraint-induced movement therapy on hand functions in post stroke hemiparetic subjects

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Abstract

Strokes are highly prevalent worldwide, and survivors often face challenges in performing upper limb activities. Upper-limb hemiparesis occurs in nearly 80 % of stroke cases, making it the most common post-stroke impairment. This study aims to compare the effectiveness of the Concise Arm Rehabilitation for Stroke Patients (CARAS) approach with Modified Constraint-Induced Movement Therapy (M-CIMT) in enhancing hand function in individuals who have experienced a stroke. Convenience sampling was used to recruit sixty post-stroke hemiparetic participants, who were then randomly assigned to two groups: the experimental group, which received the CARAS approach, and the control group, which received M-CIMT. At baseline, as well as in weeks four and eight, the interventions were evaluated. The Jebsen Taylor Hand Function Test (JTHFT), the Action Research Arm Test (ARAT), and a dynamometer were used to measure hand function, dexterity, grip strength, and pincer grasp, among other outcomes. According to preliminary findings, the CARAS group outperformed the M-CIMT group in terms of improvements in hand function and dexterity as assessed by ARAT and JTHFT. Additionally, the experimental group showed more notable improvements in pincer grasp and grip strength. Using outcome measures like the Jebsen Taylor Hand Function Test and Action Research Arm Test, the study uniquely evaluates CARAS, which emphasizes patient stratification and personalized goals, against M-CIMT. The findings could influence clinical practice by showcasing CARAS's potential benefits and offering new insights into effective rehabilitation strategies.

Keywords: Stroke, Rehabilitation, Dynamometer, CARAS, M-CIMT, Hemiparetic.

Introduction

A stroke is a rapidly developing clinical symptom of a localized neurological deficit resulting from a central nervous system vascular injury that lasts longer than twenty-four hours defined by the World Health Organization (WHO) (Aho et al., 1980; Tadi and Lui, 2023; Murphy and Werring, 2020). Stroke is the second most common cause of mortality worldwide, accounting for a large percentage of deaths and

disabilities (Katan and Luft, 2018). This showed that, as the proportion of mortality increased over the previous few decades, there had been a 26% increase in stroke deaths worldwide (Kamalakkannan et al., 2017). After a stroke, damage to the neurological system frequently causes hemiparesis, which impairs the hemiparetic side's ability to utilize its arms and hands (Smith and Tomita, 2020).

Strokes are very common in the world, and their survivors are 40% more likely to experience difficulties carrying out upper limb activities (Smith and Tomita, 2020). Numerous impairments brought on by stroke affect quality of life (Aguiar et al., 2018). One such often occurring deficit that makes managing activities of daily living (ADL) particularly difficult is upper limb involvement in hemiparesis (Yadav et al., 2016).

Hemiparesis of the contralateral upper limb affects almost 80% of stroke patients, making it the most prevalent impairment following a stroke (Ju et al., 2022). Following a stroke, hemiparesis is defined as total or partial muscle weakness or paralysis affecting either side of the body (Hattem et al., 2016). When this problem occurs, patients may exhibit related dysfunction on one or both sides of the

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body, which can make it difficult to carry out necessities of daily life and put them in danger or result in a low quality of life (Bindawas et al., 2017). The most prevalent artery, the middle cerebral artery (MCA), affects 65% of the population and is primarily associated with upper extremity deformities (Simpson et al., 2021).

Proprioceptive neuromuscular facilitation, the Bobath concept, and motor learning programs are the main therapy modalities for upper limb function in stroke patients. These modalities have also been shown to be effective for hand functions (Navarro-Orozco and Sánchez-Manso, 2023).

The intense treatment known as “modified constraint-induced movement therapy” (M-CIMT) is intended to restore function in the damaged upper limb. Modified constraint induced movement therapy (Jan et al., 2019) is the name given to this variation of Constraint-Induced Movement Therapy (CIMT). One of the most crucial stroke rehabilitation techniques is modified CIMT (M-CIMT), an effective treatment designed to improve upper limb function following a stroke. The primary mechanism of M-CIMT is to limit the less paretic side and, through focused, repeated training, improve the upper limb function of the paretic side (Palomo-Carrión et al., 2020). Treatment for constraint-induced movement therapy includes: placing a sling or mitt on the unaffected limb to prevent it from being used for 90% of waking hours; and up to 12 hours of focused, focused therapy on the affected limb (Zhang et al., 2023). In order to reverse learned non-use, increase motor function, and enhance manual dexterity in stroke survivors, modified constraint induced movement therapy. M-CIMT provides strong evidence supporting upper limb rehabilitation following stroke (Baldwin et al., 2018).

Another approach called Concise Arm and Hand Rehabilitation Approach in Stroke (CARAS) was created to help physicians in their day-to-day work while they are methodically creating the best arm-hand rehabilitation program for a patient. The CARAS succinct arm and hand rehabilitation approach allows therapists to rehabilitate stroke patients’ arm hand skill performance using a structured approach (Da Silva et al., 2019).

Four concepts form the foundation of CARAS: a) stratification of the patient group according to the degree of arm-hand disability, assessed by the Utrecht Arm-Hand Test. b) A distinct emphasis on the patient’s rehabilitation objectives and related treatment outcomes. c) The self-efficacy principle; d) the ability to quickly and systemically integrate new technology and evidence-based training components; and CARAS has shown to be workable in several stroke units in rehabilitation facilities around the Netherlands (Franck et al., 2015).

Some of these patients show improvements in their arm-hand function (AHF) and arm-hand skill performance (AHSP), which can be attributed to several factors such as their own

healing process and the therapy they get, particularly in the early stages after their stroke. Increased arm and hand use and the ability to carry out functional tasks in daily life are not always associated with improved AHF and/or AHSP capability. enhancement on a functional level. Regaining selective grip strength and/or performance, for example, may not always translate into an improvement in the day-to-day task performance of people in the post-stroke period who reside in their homes (Franck et al., 2017). The current study aimed to investigate the effect of CARAS approach vs Modified CIMT on hand function in post stroke hemiparetic subjects.

Methodology

Methods

The Institutional Ethical committee [EC-MPT/23/PHY/012] approved the research. The goal and methodology of the study were explained to the subjects. Each of the 60 participants provided written consent for participation following an explanation, and the subjects were chosen in accordance with the selection criteria. Thirty individuals were randomly assigned to both the control and experimental groups. This study was conducted in various settings like clinic, rehabilitation centre in Bengaluru.

Subject criteria

A convenience sampling technique was employed in the study, involving a total of sixty participants. The subjects were randomly assigned to the control and experimental groups, with each group consisting of thirty participants. The inclusion criteria required individuals to have a diagnosis of hemiparesis due to sub-acute ischemic stroke (Franck et al., 2021), be within the age range of 40 to 60 years, and fall under stages 4 or 5 of the Brunnstrom hand component. The exclusion criteria included individuals with a history of hemorrhagic stroke (Franck et al., 2019), hand or wrist abnormalities, hand fractures, or previous hand surgeries.

Outcome measure

An effective and valid standardized assessment tool for determining post-stroke hemiparetic upper extremity functional limits is the Action Research Arm Test. It consists of 19 items organized by difficulty into four subtests: gross motor, grasp, grip, and pinch. Either all of the items or just the pertinent ones can be evaluated when administering the test. A 4-point rating system is used to assess performance (0 being unable, 1 being partial, and 3 being typical). The total of all ratings can reach 57 points. Improved function of the upper extremities is indicated by higher scores (Grattan et al., 2019). Developed in 1969, the Jebsen-Taylor Hand Function Test (JTHFT) is used to assess hand function in patients with injuries and to evaluate the effectiveness of therapeutic interventions. Included are tasks that assess a wide variety of unimanual hand functions required for daily

activities. This exam is frequently used to measure hand dexterity and is thought to be valid for testing hand function in people with a variety of hand problems, including stroke, traumatic brain injury, and spinal cord injury (Sığirtmaç and Öksüz, 2021; Nordin et al., 2014). The Jamar dynamometer, which displays force in pounds and kilograms up to 200 lb (90 kg), is a commonly used tool for testing grip strength. It is made to be isometric, meaning that regardless of grip strength, there is no discernible handle motion, and it has a peak needle that holds the highest reading until reset. Hand sizes can be accommodated by adjusting the handle. The Jamar dynamometer exhibits good test-retest and inter-rater reliability (Hogrel et al., 2015).

Intervention

M-CIMT therapy was given to the control group five days a week for eight weeks at a time for forty minutes each. Patients were instructed to use the affected hand for a variety of tasks, including playing cards, pressing buttons, spinning pens, turning pages of magazines, picking and placing sponge balls, taking coins out of pouches, filling jars with water for glasses, and using pegboards (Arnould et al., 2004). While the non-affected hand was required to wear a glove for three hours each day. The goal of this regimen was to enhance the damaged hand's functionality and promote its use.

The CARAS approach therapy was given to the experimental group for eight weeks, five days a week, with the same forty-minute period. Patients were asked to use both hands to execute tasks including both fine and gross motor skills. Fixating bread, rolling clay, kneading dough, holding a box, opening a jar of jam, pouring liquids into a glass, sliding and cleaning a table were examples of gross motor activity (Franck et al., 2019). Therapy putty exercises (pinching, rolling with three fingers, pressing),

opening bottle caps, moving beads, stacking carrom coins, performing resistance exercises with rubber bands, rearranging a deck of cards, using a thread and needle, and tying a knot with thread were examples of fine motor activities (Arnould et al., 2004). The goal of these exercises was to increase hand strength and dexterity.

Statistical Analysis

Statistical analysis was done using chi-square test, Shapiro wilk test, Mann Whitney U test, Wilcoxon matched pairs test. Microsoft excel was used to generate tables.

Results

Table 1 shows that there is no significant difference in age distribution between Group A and Group B (Chi- square = 5.7320, $p = 0.0570$).

Table 2 shows no significant difference between Group A and Group B with gender distribution (Chi- square = 0.0670, $p = 0.7950$).

Table 3 shows the comparison of the two groups A & B with respect to height, weight and BMI using t-test.

Note that, the various parameters scores at different treatment time points in Group A and Group B not follow normal distribution (Table 4). Therefore, the non-parametric tests were applied.

- No significant difference was observed between Group A and Group B with pre-test ARAT scores ($Z = 0.0739$, $p = 0.9411$).
- A significant difference was observed between Group A and Group B with mid test ARAT scores ($Z = 6.1947$, $p = 0.0001$), with post-test ARAT scores ($Z = 6.5495$, $p = 0.0001$). It means that, a significant and higher changes in ARAT scores after mid test and post-test in Group A as compared to Group B (Table 5).
- A significant difference was observed between changes in ARAT scores from Pre-test to mid test ($Z = 4.7821$, $p =$

Table 1: Comparison of Group A and Group B with age

Age groups	Group A	%	Group B	%	Total	%	Chi-square	p-value
<=50yrs	7	23.33	9	30.00	16	26.67		
51-55yrs	21	70.00	13	43.33	34	56.67		
56-60yrs	2	6.67	8	26.67	10	16.67	5.7320	0.0570
Mean	53.07		53.53		53.30			
SD	2.55		4.23		3.47			
Total	30	100.00	30	100.00	60	100.00		

Table 2: Comparison of Group A and Group B with gender

Gender	Group A	%	Group B	%	Total	%	Chi-square	p-value
Male	17	56.67	16	53.33	33	55.00		
Female	13	43.33	14	46.67	27	45.00	0.0670	0.7950
Total	30	100.00	30	100.00	60	100.00		

Table 3: Comparison of Group A and Group B with height, weight and BMI by t test

Variables	Group A		Group B		t-value	p-value
	Mean	Std. Dev.	Mean	Std. Dev.		
Height in cms	166.17	9.65	169.30	10.02	-1.2339	0.2222
Weight in kg	69.50	11.85	65.97	9.31	1.2844	0.2041
BMI	25.01	3.53	23.07	3.02	2.2872	0.0258*

*p < 0.05

Table 4: Normality of various parameters scores at different treatment time points in Group A and Group B by Shapiro-Wilk test

Parameters	Time	Groups	Shapiro- Wilk	df	p-value
ARAT	Pretest	Group A	0.8410	30	0.0001*
		Group B	0.8410	30	0.0001*
	Mid test	Group A	0.9850	30	0.9440
		Group B	0.8200	30	0.0001*
	Posttest	Group A	0.9600	30	0.3090
		Group B	0.7780	30	0.0001*
JTHFT	Pretest	Group A	0.8500	30	0.0010*
		Group B	0.8350	30	0.0001*
	Mid test	Group A	0.8110	30	0.0001*
		Group B	0.8690	30	0.0020*
	Post test	Group A	0.8130	30	0.0001*
		Group B	0.8450	30	0.0001*
Grip strength (KG)	Pre test	Group A	0.9370	30	0.0500*
		Group B	0.9140	30	0.0180*
	Mid test	Group A	0.9590	30	0.2960
		Group B	0.9200	30	0.0270*
	Post test	Group A	0.9360	30	0.0720
		Group B	0.9360	30	0.0500*
Pincer grasp (KG)	Pre test	Group A	0.9430	30	0.1090
		Group B	0.9230	30	0.0330*
	Mid test	Group A	0.2200	30	0.0001*
		Group B	0.9320	30	0.0500*
	Post test	Group A	0.8980	30	0.0080*
		Group B	0.9650	30	0.4160

*p < 0.05

- 0.0001) with 145.06%, Pre-test to posttest (Z = 4.7824, p = 0.0001) with 192.49% in Group A (Table 6).
- A significant difference was observed between changes in ARAT scores from Pretest to mid test (Z = 4.7030, p = 0.0001) with 29.08%, Pre-test to post-test (Z = 4.7821, p = 0.0001) with 43.82% in Group B. It means, the changes significantly higher in A as compared to group B.
- No significant difference was observed between Group A and Group B with pretest JTHFT scores (Z = 0.0961, p = 0.9234).
- A significant difference was observed between Group A and Group B with mid test JTHFT scores (Z = -2.6760, p = 0.0075), with post-test JTHFT scores (Z = -3.2452, p = 0.0012). It means that, a significant and higher changes in JTHFT scores after mid test and posttest in Group A as compared to Group B (Table 7).

Table 5: Comparison of Group A and Group B with ARAT scores at different treatment time points by Mann-Whitney U test

Times	Group A			Group B			U-value	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	8.43	2.85	30.68	8.37	2.75	30.32	444.5	0.0739	0.9411
Mid test	20.67	4.23	44.48	10.80	2.77	16.52	30.5	6.1947	0.0001*
Posttest	24.67	3.84	45.28	12.03	2.67	15.72	6.5	6.5495	0.0001*
Pre to mid	12.23	4.28	44.77	2.43	1.22	16.23	22.0	6.3203	0.0001*
Pre to post	16.23	3.28	45.50	3.67	1.42	15.50	0.0	6.6456	0.0001*
Mid to post	4.00	3.11	41.58	1.23	0.97	19.42	117.5	4.9084	0.0001*

*p < 0.05

Table 6: Comparison of different treatment time points with ARAT scores Group A and Group B by Wilcoxon matched pairs test

Groups	Changes from	Mean change	% of change	Z-value	p-value
Group A	Pre-test to mid-test	12.23	145.06	4.7821	0.0001*
	Pre-test to post-test	16.23	192.49	4.7824	0.0001*
	Mid test to post-test	4.00	19.35	4.7030	0.0001*
Group B	Pretest to mid test	2.43	29.08	4.7030	0.0001*
	Pretest to posttest	3.67	43.82	4.7821	0.0001*
	Mid test to posttest	1.23	11.42	4.1706	0.0001*

*p < 0.05

Table 7: Comparison of Group A and Group B with JTHFT scores at different treatment time points by Mann-Whitney U test

Times	Group A			Group B			U-value	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	154.67	15.78	30.73	154.53	16.1	30.27	443.0	0.0961	0.9234
Mid test	141.00	15.52	24.45	149.27	16.09	36.55	268.5	-2.6760	0.0075*
Posttest	135.93	14.35	23.17	146.63	15.40	37.83	230.0	-3.2452	0.0012*
Pre to mid	13.67	3.14	44.63	5.27	3.15	16.37	26.0	6.2612	0.00011*
Pre to post	18.73	4.34	44.77	7.90	4.41	16.23	22.0	6.3203	0.0001*
Mid to post	5.07	2.84	37.42	2.63	3.50	23.58	242.5	3.0604	0.0022*

*p < 0.05

- A significant difference was observed between changes in JTHFT scores from Pretest to mid test ($Z = 4.7821$, $p = 0.0001$) with 8.84%, Pretest to posttest ($Z = 4.7824$, $p = 0.0001$) with 12.11% in Group A (Table 8).
- A significant difference was observed between changes in JTHFT scores from Pretest to mid test ($Z = 4.6382$, $p = 0.0001$) with 3.41%, Pretest to posttest ($Z = 4.6896$, $p = 0.0001$) with 5.11% in Group B. It means, the changes significantly higher in A as compared to group B.
- No significant difference was observed between Group A and Group B with pretest Grip strength (KG) scores ($Z = -0.6875$, $p = 0.4918$).
- A significant difference was observed between Group A and Group B with mid test Grip strength (KG) scores ($Z = 3.1195$, $p = 0.0018$), with post-test Grip strength (KG) scores ($Z = 5.3002$, $p = 0.0001$). It means that, a significant and higher changes in Grip strength (KG) scores after mid test and posttest in Group A as compared to Group B (Table 9).
- A significant difference was observed between changes in Grip strength (KG) scores from Pre-test to mid test ($Z = 4.7822$, $p = 0.0001$) with 97.14%, Pretest to posttest ($Z = 4.7825$, $p = 0.0001$) with 183.57% in Group A (Table 10).
- A significant difference was observed between changes in Grip strength (KG) scores from Pretest to mid test ($Z = 4.6226$, $p = 0.0001$) with 47.26%, Pre-test to post-test ($Z = 4.7821$, $p = 0.0001$) with 82.19% in Group B. It means, the changes significantly higher in A as compared to group B.
- No significant difference was observed between Group A and Group B with pretest Pincer grasp (KG) scores ($Z = -0.0148$, $p = 0.9882$).

Table 8: Comparison of different treatment time points with JTHFT scores Group A and Group B by Wilcoxon matched pairs test

Groups	Changes from	Mean change	% of change	Z-value	p-value
Group A	Pretest to mid test	13.67	8.84	4.7821	0.0001*
	Pretest to posttest	18.73	12.11	4.7824	0.0001*
	Mid test to posttest	5.07	3.59	4.7616	0.0001*
Group B	Pretest to mid test	5.27	3.41	4.6382	0.0001*
	Pretest to posttest	7.90	5.11	4.6896	0.0001*
	Mid test to posttest	2.63	1.76	3.3300	0.0009*

*p < 0.05

Table 9: Comparison of Group A and Group B with grip strength (KG) scores at different treatment time points by Mann-Whitney U test

Times	Group A			Group B			U-value	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	4.67	1.54	28.93	4.87	1.46	32.07	403.0	-0.6875	0.4918
Mid test	9.20	2.41	37.55	7.17	2.10	23.45	238.5	3.1195	0.0018*
Posttest	13.23	2.40	42.47	8.87	2.27	18.53	91.0	5.3002	0.0001*
Pre to mid	4.53	2.13	39.93	2.30	1.29	21.07	167.0	4.1766	0.0001*
Pre to post	8.57	1.77	44.88	4.00	1.46	16.12	18.5	6.3721	0.0001*
Mid to post	4.03	1.45	42.33	1.70	1.06	18.67	95.0	5.2411	0.0001*

*p < 0.05

Table 10: Comparison of different treatment time points with Grip strength (KG) scores Group A and Group B by Wilcoxon matched pairs test

Groups	Changes from	Mean change	% of change	Z-value	p-value
Group A	Pretest to mid test	4.53	97.14	4.7822	0.0001*
	Pretest to posttest	8.57	183.57	4.7825	0.0001*
	Mid test to posttest	4.03	43.84	4.7821	0.0001*
Group B	Pretest to mid test	2.30	47.26	4.6226	0.0001*
	Pretest to posttest	4.00	82.19	4.7821	0.0001*
	Mid test to posttest	1.70	23.72	4.4860	0.0001*

*p < 0.05

- No significant difference was observed between Group A and Group B with mid test Pincer grasp (KG) scores ($Z = -1.2567$, $p = 0.2089$), with post-test Pincer grasp (KG) scores ($Z = 1.5154$, $p = 0.1297$). It means that, the changes in Pincer grasp (KG) scores after mid test and post-test are similar in Group A and Group B (Table 11).
- A significant difference was observed between changes in Pincer grasp (KG) scores from Pre-test to mid test ($Z = 4.2034$, $p = 0.0001$) with 49.61%, Pre-test to posttest ($Z = 4.7821$, $p = 0.0001$) with 143.00% in Group A (Table 12).
- A significant difference was observed between changes in Pincer grasp (KG) scores from Pre-test to mid test ($Z = 4.6226$, $p = 0.0001$) with 62.59%, Pretest to posttest ($Z = 4.7821$, $p = 0.0001$) with 116.58% in Group B. It means,

the changes significantly higher in A as compared to group B.

Discussion

After a stroke, hemiparesis is the complete or partial paralysis or weakening of one or both sides of the body (Aho et al., 1980). Hemiparesis is most commonly associated with the inability to dress oneself, take care of oneself, feed oneself, and distinguish between left and right. Following diagnosis, muscle weakness prevents 80% of hemiparesis sufferers from performing activities of daily living (ADL) (Sun et al., 2021).

The primary goal of the research is to determine how the modified CIMT vs. CARAS strategy affects hand function in

Table 11: Comparison of Group A and Group B with Pincer grasp (KG) scores at different treatment time points by Mann-Whitney U test

Times	Group A		Group B			U-value	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank		
Pretest	1.55	0.63	30.45	1.57	0.63	30.55	448.5	0.9882
Mid test	2.32	0.74	27.65	2.55	0.79	33.35	364.5	0.2089
Posttest	3.77	0.84	33.93	3.40	0.82	27.07	347.0	0.1297
Pre to mid	0.77	0.62	28.08	0.98	0.57	32.92	377.5	0.2871
Pre to post	2.22	0.77	35.27	1.83	0.77	25.73	307.0	0.0351*
Mid to post	1.45	0.82	37.48	0.85	0.46	23.52	240.5	0.0020*

*p < 0.05

Table 12: Comparison of different treatment time points with Pincer grasp (KG) scores Group A and Group B by Wilcoxon matched pairs test

Groups	Changes from	Mean change	% of change	Z-value	p-value
Group A	Pretest to mid test	0.77	49.61	4.2034	0.0001*
	Pretest to posttest	2.22	143.00	4.7821	0.0001*
	Mid test to posttest	1.45	62.42	4.7821	0.0001*
Group B	Pretest to mid test	0.98	62.59	4.6226	0.0001*
	Pretest to posttest	1.83	116.58	4.7821	0.0001*
	Mid test to posttest	0.85	33.20	4.6226	0.0001*

*p < 0.05

hemiparetic post-stroke participants. Hand function values in the control group increased from 8.37 ± 2.75 at baseline to 10.80 ± 2.77 at week 4 and then to 12.03 ± 2.67 at week 8. Comparably, the experimental group's scores increased from 8.43 ± 2.85 at baseline to 20.67 ± 4.23 at week 4 and 24.67 ± 3.84 at week 8. The experimental group outperformed the control group by a wide margin. In terms of dexterity, the scores of the control and experimental groups differed significantly. The control group dexterity scores improved from a baseline of 154.53 ± 16.19 to 149.27 ± 16.09 at week 4, and this improvement was sustained through week 8 with a score of 146.63 ± 15.40 . Likewise, the experimental group showed a marked improvement from a baseline level of 154.67 ± 15.78 to 141.00 ± 15.52 at week 4, with continued improvement through week 8, reaching 135.93 ± 14.35 . The experimental group's improvement was significantly greater than that of the control group.

The pre- and post-test results for grip strength demonstrated a significant difference in mean and SD. In the control group, the grip strength scores improved from a baseline level of 4.87 ± 1.46 to 7.17 ± 2.10 at week 4, and further enhanced by week 8, reaching 8.87 ± 2.27 . In the experimental group, scores also improved from a baseline level of 4.67 ± 1.54 to 9.20 ± 2.41 at week 4, with continued progress noted at week 8, reaching 13.23 ± 2.40 . Substantial differences were revealed in the comparison between groups, with significantly better outcomes shown by the experimental group.

Both groups experienced improvement in pincer grip. The control group showed gains from a baseline of 1.57 ± 0.63 to 2.55 ± 0.79 at week 4, and further to 3.40 ± 0.82 at week 8. The experimental group, however, progressed from a baseline of 1.55 ± 0.63 to 2.32 ± 0.74 at week 4, and continued to show substantial improvement through week 8, reaching 3.77 ± 0.84 . Comparison between the experimental and control groups for both post-test 1 and post-test 2 revealed that the experimental group consistently outperformed the control group, indicated by significant differences favouring the experimental group ($p < 0.005$).

The results of the study showed that hand function had improved, which was in line with a different study conducted by Dromerick *et al.* that also showed a significant improvement in upper motor function in the subacute group (Dromerick *et al.*, 2021). This uniformity supports the efficacy and dependability of the hand function-improving therapies employed in both studies (Dromerick *et al.*, 2021).²⁹ The results of this study showed increased dexterity, which was found to be similar with findings from another study conducted by Kushnir *et al.*, who used the same test to demonstrate substantial gains in children with cerebral palsy. This resemblance demonstrates the usefulness of the Jebsen Taylor Hand Function Test in assessing and enhancing dexterity with focused interventions (Kushnir and Kachmar, 2023). In this investigation, a dynamometer was used to test pincer grasp and grip strength in order to strengthen their grasp. These results align with those

of Abdelhakiem, who found that both the experimental and control groups experienced a significant increase in hand grip strength. The outcomes of this study support the usefulness of grip strength training interventions (Abdelhakiem et al., 2024). These findings support the work by Radder *et al.*, which discovered that pinch strength rose considerably in the treatment group from pre- to post-evaluation (Radder et al., 2019). Our results, however, are in opposition to those of El-Gohary *et al.*, who found no significant differences in hand grip and pinch strength at a significance threshold of $p < 0.05$. El-Gohary *et al.* observed a considerable increase in pinch grip strength favouring the dominant hand despite these contradictory data (Fathi El-Gohary and Aljohani, 2023).

According to the 2014 study by Wolf *et al.*, hand function therapies are beneficial and in line with earlier studies for hemiparetic individuals recovering from stroke. More specifically, the findings show that these approaches improve upper extremity function in post-stroke hemiparetic individuals (Wolf et al., 2014) just as well as unimanual paretic upper extremity training regimens, but not better.

By using the non-paretic arm, performing active bilateral movements can help with recovery in the paretic arm, according to the neurophysiology literature on motor behaviour. After bimanual training, this method causes a considerable cortical remodelling. Bimanual therapy is probably most effective when corticocerebellar circuits, such as the ipsilateral cerebellum and contra lesional motor cortex, are reorganized. Both unimanual and bimanual techniques are grounded in the concepts of motor learning and brain plasticity (Bansal and Diwan, 2021).

Long-lasting gains in motor function are achieved by encouraging use-dependent plasticity through repeated practice and task-specific training. During Constraint-Induced Movement Therapy (CIMT) and Modified Constraint-Induced Movement Therapy (MCIMT), there is an increase in electrical and metabolic neuronal activity in key cortical areas, including the main motor cortex, dorsal premotor cortex, and supplementary motor area. The brain's amazing ability to adapt and restructure through concentrated and intense practice is demonstrated by these regions, which are essential for the preparation, initiation, and execution of movements (Franck et al., 2015).

The study had several limitations. With just 60 individuals, the sample size is small. Reliability requires larger sample sizes. Eight weeks was the brief duration. Longer term effects require longer term investigations. Conducted in multiple centres, with limited locations. We need more varied locations. Age or differences in the severity of strokes were not taken into account in this investigation. These characteristics ought to be used in future study to categorize subjects. After eight weeks, there were no checks. Long-term follow-ups should be a part of future research to determine

whether the advantages endure. Determine which CARAS program components are most effective at enhancing the course of therapy. To aid in making healthcare decisions, weigh the advantages and disadvantages of CARAS and M-CIMT.

Conclusion

This study demonstrates that CARAS and M-CIMT can help stroke survivors with their hand function. Future research should involve more individuals, longer study durations, and more diverse settings as this study only included 60 people and lasted eight weeks. In order to prevent bias and evaluate long-term impacts, blinding assessors and carrying out long-term follow-ups are essential. Future research should also determine which CARAS components are the most effective and assess the cost-effectiveness of CARAS and M-CIMT. By taking these actions, more stroke survivors will benefit from improved treatments.

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References

- Abdelhakiem, N. M., Mustafa Saleh, M. S., Shabana, M. M., Abd EL Wahaab, H. A., & Saleh, H. M. (2024). Effectiveness of a high-intensity laser for improving hemiplegic shoulder dysfunction: a randomized controlled trial. *Scientific Reports*, 14(1), 7346. Available from: <https://doi.org/10.1038/s41598-024-57453-9>.
- Aguiar, L. T., Nadeau, S., Britto, R. R., Teixeira-Salmela, L. F., Martins, J. C., & Faria, C. D. C. D. M. (2018). Effects of aerobic training on physical activity in people with stroke: protocol for a randomized controlled trial. *Trials*, 19, 1-8. Available from: <https://doi.org/10.1186/s13063-018-2823-0>
- Aho, K., Harmsen, P., Hatano, S., Marquardsen, J., Smirnov, V. E., & Strasser, T. (1980). Cerebrovascular disease in the community: results of a WHO collaborative study. *Bulletin of the World Health Organization*, 58(1), 113. Available from: <https://pubmed.ncbi.nlm.nih.gov/articles/PMC2395897/>
- Arnould, C., Penta, M., Renders, A., & Thonnard, J. L. (2004). ABILHAND-Kids: a measure of manual ability in children with cerebral palsy. *Neurology*, 63(6), 1045-1052. Available from: <https://doi.org/10.1212/01.wnl.0000138423.77640.37>
- Baldwin, C. R., Harry, A. J., Power, L. J., Pope, K. L., & Harding, K. E. (2018). Modified Constraint-Induced Movement Therapy is a feasible and potentially useful addition to the Community Rehabilitation tool kit after stroke: A pilot randomised control trial. *Australian occupational therapy journal*, 65(6), 503-511. Available from: <https://doi.org/10.1111/1440-1630.12488>.
- Bansal, A., & Diwan, S. (2021). Effect of Modified Constraint Induced Movement Therapy and Hand Arm Bimanual Intensive Training on Upper Extremity Skills and Functional Performance in Children with Spastic Hemiplegic Cerebral Palsy. *Int. J. Health Sci. Res*, 11, 32-43.

- Bindawas, S. M., Mawajdeh, H. M., Vennu, V. S., & Alhaidary, H. M. (2017). Functional recovery differences after stroke rehabilitation in patients with uni-or bilateral hemiparesis. *Neurosciences Journal*, 22(3), 186-191. Available from: <https://doi.org/10.17712/nsj.2017.3.20170010>
- Dromerick, A. W., Geed, S., Barth, J., Brady, K., Giannetti, M. L., Mitchell, A., ... & Edwards, D. F. (2021). Critical Period After Stroke Study (CPASS): A phase II clinical trial testing an optimal time for motor recovery after stroke in humans. *Proceedings of the National Academy of Sciences*, 118(39), e2026676118. Available from: <https://doi.org/10.1073/pnas.2026676118>
- El-Gohary, T. M. F., & Aljohani, M. M. (2023). Effect of texting and handwriting on hand-grip and key-pinch strength among female-collegiate students: randomized controlled trial. *JPMa*, 73(1577), 1-19. Available from: <https://doi.org/10.47391/JPMa.1577>
- Franck, J. A., Halfens, J., Smeets, R., & Seelen, H. (2015). Concise Arm and hand Rehabilitation Approach in Stroke (CARAS): A practical and evidence-based framework for clinical rehabilitation management. *The Open Journal of Occupational Therapy*, 3(4), 10.
- Franck, J. A., Smeets, R. J. E. M., & Seelen, H. A. M. (2017). Changes in arm-hand function and arm-hand skill performance in patients after stroke during and after rehabilitation. *PloS one*, 12(6), e0179453. Available from: <https://doi.org/10.1371/journal.pone.0179453>
- Franck, J. A., Smeets, R. J. E. M., & Seelen, H. A. M. (2019). Changes in actual arm-hand use in stroke patients during and after clinical rehabilitation involving a well-defined arm-hand rehabilitation program: A prospective cohort study. *PloS one*, 14(4), e0214651. Available from: <https://doi.org/10.1371/journal.pone.0214651>
- Franck, J. A., Smeets, R. J. E. M., Elmanowski, J., Renders, K., & Seelen, H. A. M. (2021). Added-value of spasticity reduction to improve arm-hand skill performance in sub-acute stroke patients with a moderately to severely affected arm-hand. *NeuroRehabilitation*, 48(3), 321-336. Available from: <https://doi.org/10.3233/NRE-201622>
- Grattan, E. S., Velozo, C. A., Skidmore, E. R., Page, S. J., & Woodbury, M. L. (2019). Interpreting action research arm test assessment scores to plan treatment. *OTJR: occupation, participation and health*, 39(1), 64-73. Available from: <https://doi.org/10.1177/1539449218757740>
- Hatem, S. M., Saussez, G., Della Faille, M., Prist, V., Zhang, X., Dispa, D., & Bleyenheuft, Y. (2016). Rehabilitation of motor function after stroke: a multiple systematic review focused on techniques to stimulate upper extremity recovery. *Frontiers in human neuroscience*, 10, 442. Available from: <https://doi.org/10.3389/fnhum.2016.00442>
- Hogrel, J. Y. (2015). Grip strength measured by high precision dynamometry in healthy subjects from 5 to 80 years. *BMC musculoskeletal disorders*, 16, 1-12. Available from: <https://doi.org/10.1186/s12891-015-0612-4>
- Jan, S., Arsh, A., Darain, H., & Gul, S. (2019). A randomized control trial comparing the effects of motor relearning programme and mirror therapy for improving upper limb motor functions in stroke patients. *JPMa*, 69(1242), 2019.
- Ju, Y. W., Lee, J. S., Choi, Y. A., & Kim, Y. H. (2022). Causes and trends of disabilities in community-dwelling stroke survivors: a population-based study. *Brain & Neurorehabilitation*, 15(1), e5. Available from: <https://doi.org/10.12786/bn.2022.15.e5>
- Kamalakannan, S., Gudlavalleti, A. S., Gudlavalleti, V. S. M., Goenka, S., & Kuper, H. (2017). Incidence & prevalence of stroke in India: A systematic review. *Indian Journal of Medical Research*, 146(2), 175-185. Available from: https://doi.org/10.4103/ijmr.IJMR_516_15
- Katan, M., & Luft, A. (2018, April). Global burden of stroke. In *Seminars in neurology* (Vol. 38, No. 02, pp. 208-211). Thieme Medical Publishers. Available from: <https://doi.org/10.1055/s-0038-1649503>
- Kushnir, A., & Kachmar, O. (2023). Intensive Neurophysiological Rehabilitation System for children with cerebral palsy: a quasi-randomized controlled trial. *BMC neurology*, 23(1), 157. Available from: <https://doi.org/10.1186/s12883-023-03216-4>
- Margetis, K., & Sánchez-Manso, J. C. (2025). Neuroanatomy, middle cerebral artery. In *StatPearls [Internet]*. StatPearls Publishing.
- Murphy, S. J., & Werring, D. J. (2020). Stroke: causes and clinical features. *Medicine*, 48(9), 561-566. Available from: <https://doi.org/10.1016/j.mpmed.2020.06.002>
- Nordin, Å., Murphy, M. A., & Danielsson, A. (2014). Intra-rater and inter-rater reliability at the item level of the Action Research Arm Test for patients with stroke. *Journal of rehabilitation medicine*, 46(8), 738-745. Available from: <https://doi.org/10.2340/16501977-1831>
- Palomo-Carrión, R., Romay-Barrero, H., Romero-Galisteo, R. P., Pinero-Pinto, E., López-Muñoz, P., & Martínez-Galán, I. (2020). Modified constraint-Induced movement therapy at home—is it possible? Families and children's experience. *Children*, 7(11), 248. 2020. Available from: <https://doi.org/10.3390/children7110248>
- Radder, B., Prange-Lasonder, G. B., Kottink, A. I., Holmberg, J., Sletta, K., van Dijk, M., ... & Rietman, J. S. (2019). Home rehabilitation supported by a wearable soft-robotic device for improving hand function in older adults: A pilot randomized controlled trial. *PloS one*, 14(8), e0220544. Available from: <https://doi.org/10.1371/journal.pone.0220544>
- Siğırtmaç, İ. C., & Öksüz, Ç. (2021). Investigation of reliability, validity, and cutoff value of the Jebsen-Taylor Hand Function Test. *Journal of Hand Therapy*, 34(3), 396-403. Available from: <https://doi.org/10.1016/j.jht.2020.01.004>
- Simpson, L. A., Hayward, K. S., McPeake, M., Field, T. S., & Eng, J. J. (2021). Challenges of estimating accurate prevalence of arm weakness early after stroke. *Neurorehabilitation and Neural Repair*, 35(10), 871-879. Available from: <https://doi.org/10.1177/15459683211028240>
- Smith, M. A., & Tomita, M. R. (2020). Combined effects of telehealth and modified constraint-induced movement therapy for individuals with chronic hemiparesis. *International Journal of Telerehabilitation*, 12(1), 51. Available from: <https://doi.org/10.5195/ijt.2020.6300>
- Sun, X., Xu, K., Shi, Y., Li, H., Li, R., Yang, S., ... & Yang, T. (2021). Discussion on the rehabilitation of stroke hemiplegia based on interdisciplinary combination of medicine and engineering. *Evidence-Based Complementary and Alternative Medicine*, 2021(1), 6631835. Available from: <https://doi.org/10.1155/2021/6631835>
- Tadi P, Lui F. *Acute Stroke*. Treasure Island (FL): StatPearls Publishing, 2023.
- Wolf, A., Scheiderer, R., Napolitan, N., Belden, C., Shaub, L., &

- Whitford, M. (2014). Efficacy and task structure of bimanual training post stroke: a systematic review. *Topics in stroke rehabilitation*, 21(3), 181-196. Available from: <https://doi.org/10.1310/tsr2103-181>
- Yadav, R. K., Sharma, R., Borah, D., & Kothari, S. Y. (2016). Efficacy of modified constraint induced movement therapy in the treatment of hemiparetic upper limb in stroke patients: a randomized controlled trial. *Journal of clinical and diagnostic research: JCDR*, 10(11), YC01. Available from: <https://doi.org/10.7860/JCDR/2016/23468.8899>