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Effectiveness of unilateral and symmetrical bilateral task training for arm during the subacute phase after stroke: a randomized controlled trial

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Objective: To evaluate the effect of an arm training programme combining repetition of unilateral and symmetrical bilateral tasks for people in the subacute phase after stroke.
Design: Randomized controlled trial.
Setting: Inpatient functional rehabilitation unit.
Subjects: Forty-one people who had had a stroke, in the subacute phase, receiving conventional arm occupational and physical therapy, were randomized to an experimental group ($n = 20$) and a control group ($n = 21$).
Interventions: In addition to the usual arm therapy in the rehabilitation unit, the experimental group received an arm therapy programme (15–20 45-min sessions) based on repetition of unilateral and symmetrical bilateral tasks. The control group received additional usual arm therapy of a similar duration and frequency to the experimental treatment.
Main measures: The effect of the programme was judged on the basis of: (1) arm impairments (motor function, grip strength, gross and fine manual dexterity and motor co-ordination), (2) arm disabilities in tasks related to daily activities, and (3) functional independence in activities of daily living (ADL) and instrumental ADL (IADL).
Results: Although both experimental and control groups of participants improved similarly during the study period, the statistical analyses did not show any difference between the groups at the end of the treatment for the different dependent variables evaluated: (1) arm impairments: $p = 0.43–0.79$; (2) arm disabilities: $p = 0.16–0.90$; and (3) functional independence: $p = 0.63$ and 0.90.
Conclusions: An arm training programme based on repetition of unilateral and symmetrical bilateral practice did not reduce impairment and disabilities nor improve functional outcomes in the subacute phase after stroke more than the usual therapy.

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Introduction

Many people who have had a stroke live with significant sensorimotor impairments and disabilities that will have a considerable impact on their level of functional independence.[1] Adequate arm performance is necessary for many of the skills required for functional independence.[2] For example, numerous daily living tasks are dependent on good arm performance, which is often lost or reduced in the arm contralateral to the brain lesion (hereinafter called the affected arm). Recent studies have also reported impairments, albeit less obvious, ipsilateral to the lesion (hereinafter called the less affected side).[3,4]

The effectiveness of treatments based on neurodevelopmental techniques,[5–8] repetitive unilateral[9] or bilateral[10–12] training techniques, sensorimotor training[13] or constraint-induced therapy[14–16] has been evaluated on the motor performance of the affected arm of subjects with stroke. In general, the results indicated that neurodevelopment techniques are not superior to other therapeutic approaches[5–8] and even less effective than some contemporary approaches such as motor relearning programmes.[17]

Several studies indicated that repetitive exercises could improve motor performance of the arm in people with a stroke. Following a multiple baseline design study, Buterfisch and colleagues[9] found that unilateral repetitive strength exercises of the affected hand were more effective than conventional Bobath physical therapy to improve hand function in the subacute phase. Using the same research design, Woldag and collaborators[18] reported no additional benefit of repetitive training of complex movements to improve arm function in the subacute phase when added to a functional approach used in occupational and physical therapy. In addition, Dickstein and colleagues[7] reported that repeated unilateral complex movement therapy of the arm has no additional effect on arm motor function or independence in activities of daily living (ADL) compared with conventional treatment. However, Whitall and collaborators[12] found that repetitive bilateral training with rhythmic auditory cueing may improve arm function but not range of motion in people with stroke. Recently, this bilateral therapy was studied in a randomized controlled clinical trial with people in the chronic phase.[19] No difference in arm function was found between the experimental group ($n = 9$) and control group ($n = 12$) except with experimental patients in whom a change in hemispherical activation was found. Overall, these data suggest that bilateral repetitive training may improve arm function of people in chronic phase.

In addition, there is some evidence to suggest that symmetrical bilateral repetition of a task is also effective in the subacute phase after stroke. In the studies of Mudie and Matyas,[10,11] the experimental treatment consisted of tasks executed simultaneously but independently by both arms. This treatment was compared with unilateral performance of the same tasks and bilateral practice with both hands held together using a single-case design. The results suggest that bilateral practice with independent use of the two arms had a superior effect on the quality of the movement of the paretic arm evaluated during the tasks executed unilaterally. In view of the importance of the independent and complementary use of both arms in ADL, this approach appears interesting.

The aim of the study was to evaluate the effect of an arm retraining programme that combined unilateral and symmetrical bilateral training for people in the subacute phase following stroke. The effect of the programme was judged primarily on the basis of arm impairments (motor function, grip strength, gross and fine manual dexterity and motor co-ordination) and arm disabilities in tasks related to daily activities. Second, the effect of the programme was judged on the basis of functional independence in ADL and instrumental ADL (IADL).

Methodology

Participants

The participants were recruited from clients recently admitted to the inpatient rehabilitation unit of the Sherbrooke Geriatric University Institute, Sherbrooke, Quebec, Canada. Inclusion criteria for the study were: (1) have had a unilateral stroke, occurring at least 10 days and not more than two months earlier; (2) cognitive functioning within normal limits (above the 5th percentile) according to age and schooling on the Modified Mini-Mental State Examination;[20] (3) understand

spoken French or English; and (4) minimal upper extremity motor function (stage 2 for the hand and stage 3 for the arm as identified by the impairment inventory of the Chedoke–McMaster Stroke Assessment[21]). People were excluded if they presented severe unilateral body neglect (clinical judgement based on observation) or visual perception deficits as measured with the Motor-free Visual Perceptual Test, Vertical version[22] (minimum score: 24 out of 36).

Potential participants were contacted in the week following their admission. If they met the criteria, they were asked to participate and sign a consent form. Certain characteristics of those who met the criteria but refused to participate in the study were collected. Also, for each subject excluded, the inclusion criteria that were not met were noted. This study was approved by the Research Ethics Committee of the Sherbrooke Geriatric University Institute.

Study design and procedures

The study used a pretest–posttest experimental design with a control group. The sample was stratified on two variables: *impairment level of the hand* (Chedoke–McMaster scale score: 2, 3 or 4 versus 5, 6 or 7) and *sensibility of the hand* (normal versus reduced). This stratification was performed since recovery profile is influenced by the initial stage,[23,24] and sensibility of the hand may influence arm performance.[25] The participants were then randomly assigned to one of the two groups (experimental or control) by a block randomization scheme within each stratum. Randomization was done in blocks of four and the patient's allocation was signified to the research assistant through a sealed envelope.

Both experimental and control subjects continued to receive their usual occupational therapy and physical therapy treatments for retraining the affected arm. The experimental group subjects also received the new arm retraining programme given by an occupational therapist (OT) research assistant. To avoid possible bias associated with different therapy duration and frequency, the control subjects also received equivalent additional arm therapy, given by the same OT research assistant, based on the conventional approach currently used at the Institute (see below). Treatment duration and frequency were the same for both groups, namely four 45-min sessions per week for five weeks, for a total of between 15 and 20 sessions. The characteristics of those who dropped out during the study were documented with sociodemographic, clinical and control variables available at pretest.

The subjects were evaluated before and at the end of the programme by an independent evaluator blinded as to which group the participants belonged. The evaluations were completed in one or two sessions, depending on the participant's tolerance. The test order was modified for each subject but the same order was followed for both measurement times of the same subject.

Experimental programme

The experimental group received a training programme mainly based on the practice of symmetrical bilateral tasks. The experimental programme was also based on motor learning model principles, including repeated practice and task variability[26] (see Appendix for a specific example of the programme). The programme consisted of standardized activities related to everyday tasks involving the arms. The activities were graduated in terms of difficulty and task requirements, according to the impairment level of the arm of each experimental group participant. The tasks required the subject's active participation. There were various types of tasks: symmetrical and asymmetrical bilateral, unilateral for the affected side and unilateral for the less affected side. The symmetrical bilateral tasks involved reciprocal or similar use of the two arms (such as wringing a garment, rolling a cylinder or doing unilateral tasks simultaneously with both arms) while the asymmetrical bilateral tasks involved greater use of one of the arms (such as making coffee). This type of bilateral task can also be done with minimal capacities in the affected arm, which allows the programme to be used with patients with moderate to severe deficits. The unilateral tasks for the affected side consisted of gross and fine dexterity tasks, depending on the impairment. The unilateral tasks for the 'less affected' side mainly comprised dexterity and motor co-ordination activities requiring some precision and speed. These latter activities were retained because practising fine motor unilateral tasks on the less affected side could help improve the affected side.[27]

Control programme

The control programme for the arm consisted of functional activities and exercises to enhance strength, active, assisted and passive movements, and sensorimotor skills of the arm. The control programme was also based on some components of a neurodevelopmental approach by inhibiting abnormal patterns of movement and stimulating normal active reactions of the affected arm. The programme began with passive and assisted movements of the affected arm, followed by unilateral tasks, such as putting blocks or cones in a pile, unscrewing a light bulb, and symmetrical bilateral tasks, such as shuffling playing cards, putting a pillow in a pillowcase, tearing up sheets of paper. These tasks were adapted to the level of impairment and recovery of each patient. No asymmetrical tasks were done nor were unilateral tasks of the less affected arm done. Contrary to the experimental programme, the tasks were not repeated in a systematic way and the mental and physical effort required by the patient was lower (less intense).

Variables and measurement instruments

Dependent variables

Arm impairment was measured with different tests frequently used in rehabilitation and recognized as being responsive to clinically important change. *Motor function* of the affected arm was evaluated using Part 1 – Upper extremity motor subtest of the Fugl-Meyer evaluation.[28,29] The score ranges from 0 (no motor function) to 66 (good motor function). *Grip strength* was measured with the Martin vigorimeter and recorded in kilopascals.[30,31] The mean of three trials was used. *Gross manual dexterity* was measured with the Box and Block Test.[32] This test consists of moving, one at a time in a 60-s period, the maximum number of blocks from one side to the other of a box separated in the middle.[33,34] The number of blocks moved in 60 s is the score. *Fine manual dexterity* was measured with the Purdue Pegboard Test.[35,36] In this test, the subject has to pick up and place small metal pegs in small holes in a standardized board within a 30-s period. Finally, *motor coordination* was estimated with the Finger-to-Nose Test.[37] In this test, subjects must move their arm in a specific trajectory as quickly as possible.[38] The score is the number of movements executed in 20 s.

Arm disabilities were estimated from the four unilateral and five bilateral tasks of the TEMPA.[39,40] These are tasks related to daily living, such as pouring water into a glass, making coffee, handling coins, tying a scarf around one's neck. The functional score for the tasks is measured on a 4-point scale (0: no deficit to 3: unable to do the task). Three scores are obtained: total score on the unilateral tasks for the affected side (0–12), total score on the bilateral tasks (0–15), and total score on the unilateral and bilateral tasks (0–27). A lower score indicates a better performance.

Functional independence in ADL was estimated from the 'personal care' section of the Mesure de l'indépendance fonctionnelle (MIF), the French translation of the Functional Independence Measure (FIM).[41] Each item is scored on a 7-point scale from 1 (total dependence) to 7 (total independence) for a continuous score ranging from 7 to 42 points. The Assessment of Motor and Process Skills (AMPS)[42] was used to evaluate if there were any changes in ARM integration and use in IADL.

Sociodemographic, clinical and control variables

The usual sociodemographic and clinical data were also collected to build the profile of the study participants. Other variables that may play a role in arm sensorimotor and functional recovery or functional recovery in ADL and IADL were collected as control variables (premorbid functional independence, depressive affect,[43] comorbidity[44] rehabilitation duration, time between stroke and the beginning of inpatient rehabilitation, motivation/co-operation). Each participant's motivation/collaboration in regard to the rehabilitation programme was evaluated by the rehabilitation team at the end of the first interdisciplinary meeting using a scale from excellent to poor based on specific and observable criteria that are known to be associated with motivation, such as perseverance, assiduity and interest.

Statistical analyses

The presence of a refusal bias and dropout bias was first checked using the Mann–Whitney test for the continuous variables and the chi-squared test or Fisher's exact test for the categorical variables.

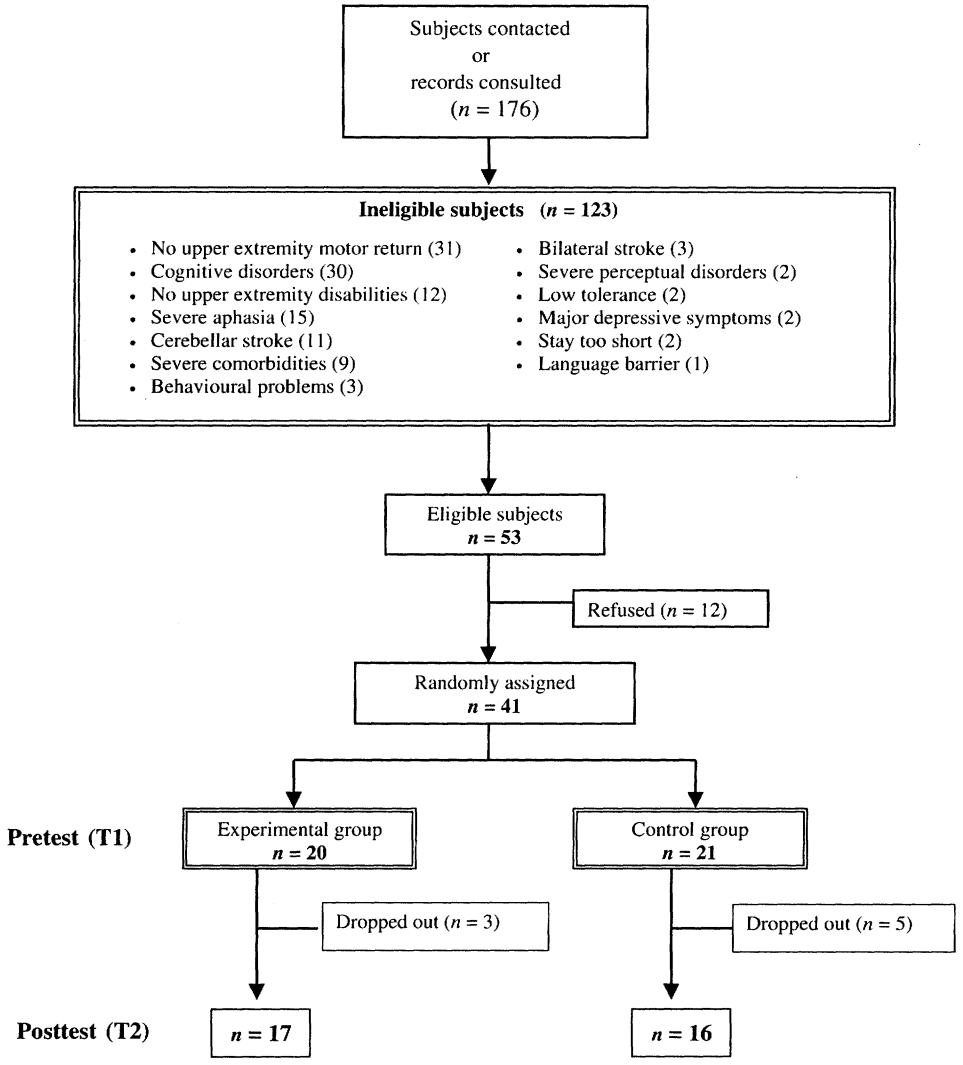

Figure 1 Flowchart of the participants.

The comparability of the two groups of subjects was verified at pretest on all the dependent and control variables. Nonparametric analyses were used because of the sample size. The dependent variables for the two groups were first compared at pretest and posttest using the Mann–Whitney test. We then looked at each group to see if there had been an improvement or any gains between pretest and posttest using the Wilcoxon signed rank test. Finally, the Mann–Whitney test was used to ascertain if the experimental group had improved more than the control group on the dependent variables and to estimate the difference, if any, in the gains in the two groups.

Results

A flowchart of the participants is presented in Figure 1. A total of 176 people or medical records were consulted leading to 53 eligible subjects

(ineligibility reasons are indicated in the figure). Of these, 12 refused to participate, mainly because of a lack of motivation, leaving 41 subjects at pretest. Those who refused did not differ from those who agreed on the variables measured (age, gender, side of stroke, type of stroke and territory of stroke) (Table 1). Those who agreed to participate ($n = 41$) were randomly assigned to the experimental ($n = 20$) and control ($n = 21$) groups.

Eight of the 41 participants at pretest dropped out during the experimental period, 3 from the experimental group and 5 from the control group, leaving 17 in the experimental group and 16 in the control group. The reasons for dropping out were: death, fracture and refusal to continue for the experimental group, and lack of interest (2), early release, fatigue and death for the control group. No statistical difference was found between the participants at pretest and posttest ($n = 33$) and the drop-outs ($n = 8$) on the sociodemographic, clinical and control variables with the exception of motivation/collaboration, those who dropped out being less motivated in therapy ($p = 0.04$).

Table 1 Estimate of refusal bias

Variables	Participants at T1 ($n = 41$)	Refusals ($n = 12$)	*p*-value[c]
Age	73.2 (10.4)[a]	75.7 (16.6)	0.07
Gender			
Women	22 (53.7)[b]	6 (50.0)	0.82
Men	19 (46.3)	6 (50.0)	
Stroke side			
Right	23 (56.1)	2 (20.0)	0.08
Left	18 (43.9)	8 (80.0)	
Missing data		2	
Stroke type			
Ischaemic	40 (97.6)	10 (83.3)	0.13
Haemorrhagic	1 (2.4)	2 (16.7)	
Stroke territory			
Lacunar	20 (50.0)	3 (33.3)	0.6
Sylvian	15 (37.5)	5 (55.5)	
Vertebrobasilar	5 (12.5)	1 (11.1)	
Missing data		3	

[a]Mean (standard deviation).
[b]Frequency (%).
[c]*p*-value associated with Mann–Whitney test for the continuous variable and chi-squared test or Fisher's exact test for the categorical variables.

As shown in Table 2, the subjects in both groups were equivalent on the sociodemographic, clinical and control variables, indicating that the stratified randomization was effective. In addition, at T1, the groups were statistically equivalent on the dependent variables (Table 3), although the control group appears to have higher scores. Finally, the statistical analyses of the dependent variables do not show any effect of the programme (Table 3). In fact, except for grip strength in both groups as well as fine manual dexterity and the score on uni- and bilateral functional tasks for the control group, both groups of participants improved during the study period, but neither significantly more than the other as shown by the *p*-values on the differences between the groups (last column).

Discussion

This study indicates that in the subacute phase after stroke, an arm training programme based on motor learning principles and the practice of bilateral tasks did not prove to be more effective than a sensorimotor stimulation activities programme. It is clear that the experimental treatment differs from the control treatment (denser and more intense, requiring more mental and physical effort even though they had the same duration) but does not improve outcomes.

The experimental group did not improve more than the control group on all the impairment and disability variables that were measured nor on functional outcomes. This result has to be discussed in light of the study limitations, including the relatively small number of participants resulting in a difficulty detecting a relatively small difference, the level of severity of the participants' impairments, and potential insensitivities in the measures. Despite a smaller sample size than originally sought (26 per group), the *p* values obtained on the inter-group differences are so far from the usual significance level (0.05) that a lack of statistical power (type II error) is an unlikely explanation. In addition, the performance improvement differences between the groups on the tests are very small and not clinically significant. Participants in both groups were mild to moderate involved patients (based on the Fugl-Meyer

Table 2 Comparison of experimental and control groups on the sociodemographic, clinical and control variables at pretest (T1)

	Experimental group ($n = 20$)	Control group ($n = 21$)	p-value[c]
Continuous variables[a]			
Age	72.2 (10.8)	74.3 (10.1)	0.52
Mental functions (3MS; /100)	83.5 (13.4)	86.1 (8.9)	0.75
Visual perception (MVPT; /36)	27.0 (5.6)	26.8 (5.4)	0.91
Pre-stroke functional independence (MIF; /126)	124.1 (4.1)	117.0 (18.9)	0.11
Depressive affect (Beck Depression Inventory; /63) (at T2)	10.1 (10.3)	11.6 (12.2)	0.61
Comorbidities (number)	8.7 (5.4)	8.9 (4.4)	0.89
Time between stroke and admission to rehabilitation (days)	34.2 (34.4)	35.4 (33.7)	0.91
Arm motor function (Chedoke; /7)	4.5 (1.4)	4.9 (1.3)	0.41
Hand motor function (Chedoke; /7)	4.3 (1.3)	4.9 (1.1)	0.70
Categorical variables[b]			
Gender			
Women	11 (55.0)	11 (52.4)	0.87
Men	9 (45.0)	10 (47.6)	
Stroke type			
Ischaemic	19 (95.0)	21 (100)	0.49
Haemorrhagic	1 (5.0)	0 (0.0)	
Stroke side			
Right	7 (35.0)	11 (52.4)	0.35
Left	13 (65.0)	10 (47.6)	
Stroke territory			
Lacunar	9 (47.4)	11 (52.4)	0.83
Sylvian	7 (36.8)	8 (38.1)	
Vertebrobasilar	3 (15.8)	2 (9.5)	
Taking antidepressants	4 (20.0)	3 (14.3)	0.69
Taking cardiovascular medication	18 (90.0)	19 (90.5)	1.00
Prestroke living environment			
Home, alone	7 (35.0)	5 (23.8)	0.56
Home, with spouse	7 (35.0)	11 (52.4)	
Home, with others	4 (20.0)	2 (9.5)	
Seniors' private residence	2 (10.0)	3 (14.3)	
Marital status			
Single/widowed	10 (50.0)	7 (33.3)	0.54
Married/common-law	8 (40.0)	9 (42.9)	
Divorced/separated	2 (10.0)	5 (23.8)	
Language			
French	19 (95.0)	18 (85.7)	0.61
English	1 (5.0)	3 (14.3)	
Motivation/collaboration			
Excellent	12 (66.7)	6 (33.3)	0.08
Good	3 (16.7)	9 (50.0)	
Fair	3 (16.7)	3 (16.7)	
Missing data	2	3	
Education (years)			
1–4	2 (10.0)	3 (14.3)	0.89
5–8	7 (35.0)	8 (38.1)	
9–13	8 (40.0)	6 (28.6)	
14–17	2 (10.0)	2 (9.5)	
18 and over	1 (5.0)	2 (9.5)	

Table 2 (*Continued*)

	Experimental group ($n = 20$)	Control group ($n = 21$)	p-value[c]
Language comprehension			
Simple instructions	1 (5.0)	1 (4.8)	0.97
Slightly complex instructions	6 (30.0)	7 (33.3)	
Complex instructions	13 (65.0)	13 (61.9)	
Language expression			
Words adapted to situations	1 (5.0)	0 (0.0)	0.44
Short sentences	2 (10.0)	4 (19.0)	
Normal	17 (85.0)	17 (81.0)	

[a]Mean (standard deviation).
[b]Frequency (%).
[c]p-value associated with Mann–Whitney test for the continuous variables and chi-squared test or Fisher's exact test for the categorical variables.

Table 3 Comparison of experimental and control groups on the dependent variables

		Experimental group		Control group		p-value[b] between groups by measurement time	p-value[b] on differences between the groups
		Mean (SD)	p-value[a] T1 vs. T2	Mean (SD)	p-value[a] T1 vs. T2		
Upper extremity sensorimotor impairments (affected side)							
Motor function	T1	42.9 (20.0)	0.046	47.0 (16.1)	0.07	0.4	0.79
(Fugl-Meyer; /66)	T2	46.1 (18.4)		51.3 (14.1)		0.49	
Grip strength	T1	24.8 (23.5)	0.16	29.1 (24.8)	0.05	0.5	0.77
(Martin vigorimeter; kPa)	T2	26.4 (25.4)		31.1 (28.8)		0.74	
Gross manual dexterity	T1	15.7 (14.3)	0.007	20.4 (16.5)	0.008	0.36	0.54
(Box & Block test; no. of blocks)	T2	23.5 (14.3)		26.6 (16.5)		0.47	
Fine manual dexterity	T1	2.2 (2.6)	0.01	4.3 (6.9)	0.11	0.46	0.74
(Purdue Pegboard; no. of pegs)	T2	3.2 (3.1)		4.3 (3.2)		0.38	
Motor co-ordination	T1	6.5 (4.4)	0.04	6.9 (5.1)	0.008	0.98	0.43
(Finger-to-Nose Test; no. of movements in 20 s)	T2	8.1 (5.8)		10.2 (7.4)		0.54	
Upper extremity functional disabilities (TEMPA)							
Unilateral tasks, affected side	T1	7.6 (4.0)	0.002	5.6 (4.6)	0.04	0.16	0.16
(0–12)	T2	4.8 (4.4)		4.0 (3.7)		0.66	
Bilateral tasks (0–15)	T1	4.1 (2.3)	0.03	3.3 (2.9)	0.02	0.26	0.9
	T2	2.9 (2.1)		1.6 (2.1)		0.03	
Unilateral + bilateral tasks (0–27)	T1	11.8 (5.4)	0.001	8.8 (7.0)	0.13	0.17	0.4
	T2	7.8 (6.3)		5.6 (5.4)		0.28	
Functioning in ADL and IADL							
ADL (MIF) (/42)	T1	31.0 (7.0)	0.002	28.3 (9.3)	0.002	0.61	0.9
	T2	35.6 (4.7)		33.2 (9.0)		0.9	
IADL (AMPS) (/3)	T1	0.42 (0.8)	0.006	0.45 (0.9)	0.001	0.71	0.63
	T2	1.3 (0.9)		1.2 (1.0)		0.35	

[a]p-value associated with Wilcoxon signed rank test.
[b]p-value associated with Mann–Whitney test.
MIF, Mesure de l'indépendance fonctionelle; AMPS, Assessment of Motor and Process Skills.

scores), which limits the external validity of the study and may contribute to the lack of difference between the two approaches owing to ceiling effects. However, some studies have demonstrated significant improvements following different treatments in a similar population of subjects to the one used in the present study. For example, two-thirds of the participants in the study of Butefisch and colleagues[9] were mild to moderate involved patients and improved following repetitive exercises. In addition, significant improvements in motor performance of the arm of mild stroke patients (with a mean Fugl-Meyer of 47 at baseline, which is similar to our study) using the Action Research Arm Test but not the Fugl-Meyer Assessment were demonstrated following a constraint-induced treatment of the paretic arm.[16] It is interesting to note that the difference in the treatments between the experimental and control group tend to be significant on the affected side using the TEMPA, which is a test similar to the Action Research Arm Test, while the changes in the Fugl-Meyer Assessment were small. This raises questions about the sensitivity of the Fugl-Meyer Assessment, particularly with stroke patients who have a higher motor performance score.

Contamination between the groups is unlikely since the professionals involved were not informed of the study objectives, hypotheses and methodology. All they were told was that a study on arm performance was being conducted. The therapists were asked not to question the clients in this regard. Also, the participants were asked not to discuss the intervention with their respective therapists or with the blind evaluator at posttest. The duration and frequency of treatment were similar for the two groups but the experimental programme required more effort on the part of the participants.

There may be a variety of reasons why the programme was not more effective. It is rare for an arm therapy trial like this to be done with clients during spontaneous recovery in the subacute phase (average of 35 days poststroke, see Table 2). The potential effect of the programme may have been hidden by the spontaneous recovery of the participants. Many arm studies, such as the majority of those on constraint-induced movement therapy, were carried out with subjects whose stroke occurred more than six or 12 months earlier (chronic phase). It is possible that deconditioning of the arm caused by less use of the extremity in the chronic phase would lead to a better effect after a specific arm therapy programme. According to some authors,[45] studies on the effectiveness of new types of arm therapies should be done within four months poststroke, when the surviving brain tissue has greater plasticity. In addition, very few rehabilitation services are offered to people in the chronic phase of a stroke as opposed to those in acute and subacute phases, reinforcing the need to study new interventions during the usual rehabilitation phase.

Also, the frequency and duration of the programme may not have been optimal. One may ask whether 15–20 45-min sessions devoted to the bilateral and unilateral tasks are sufficient to trigger brain reorganization and to observe a change. This schedule was based on practical reasons and although it is similar to those used in previous studies (e.g., refs 9 and 46), it has never been experimentally proven to be the optimal dose. More important is the fact that the participants in both groups received high level of stimulation in the rehabilitation programme, leading to the possibility of a saturation effect in arm recovery. In fact, the participants in both groups were stimulated every day to use their arms in their daily activities. Therefore, the technique used to promote better recovery could not have had any impact on the final result during the first few months of spontaneous recovery. In other words, regardless of the technique used, perhaps the important thing in the spontaneous recovery and rehabilitation period is to provide patients with

Clinical message

- In the subacute phase of stroke, an arm retraining programme based on motor learning principles and the practice of both unilateral and symmetrical bilateral tasks is no more effective in reducing short-term impairment and disability than the use of diverse sensorimotor stimulation activities.

frequent and continuous opportunities to use their arms in their activities.

The results of this study are in agreement with those of Woldag and collaborators,[18] who did not find any benefits from adding repetition of complex hand and arm movement training to the usual occupational and physical therapy. However, more recently, in a well-designed study carried out with people in the acute phase of stroke, Winstein and colleagues[46] found that task-specific functional training focusing on systematic and repetitive practice of tasks, such as in our programme, when added to arm standard care, was more effective in improving the Fugl-Meyer motor function score and strength (isometric torque) than standard care alone. These researchers excluded the extra therapy in terms of duration (20 h) as the potential explanation of the superiority of the task-specific functional training approach since this approach continues to be more effective nine months later.

To summarize, this study found that the addition of a programme based on unilateral and symmetrical bilateral tasks and motor learning principles was no more effective in increasing arm performance than a conventional approach during the subacute phase of a stroke.

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Appendix

This appendix presents an example of a programme session for the experimental group participants who had a stage 4 on the impairment inventory for the arm and hand of the Chedoke–McMaster Stroke Assessment. *Sessions like this were prepared for all stages of impairment of the arm and hand eligible for the study.*

1) Description of stage 4 of the Chedoke–McMaster Stroke Assessment

Arm: The person can perform movements combining flexor and extensor synergies. Shoulder anterior flexion and elbow flexion are possible up to at least 90°, forearm supination and pronation are performed without the influence of primitive synergies.
Hand: The person can open and close his/her fingers (flexion and massive extension). The thumb can be extended to more than half the range of motion and the lateral pinch can be performed.

2) Tasks

Following is an example of six tasks that were included in an experimental programme session. These tasks are varied in nature and are graduated in terms of difficulty:

- Task A (TA): fold hand towels (bilateral, asymmetrical task)
- Task B (TB): wipe the table (unilateral task performed bilaterally, i.e., affected and less affected sides simultaneously)
- Task C (TC): sort buttons quickly (unilateral task, less affected side)
- Task D (TD): roll out dough (bilateral, symmetrical task)
- Task E (TE): open and close various types of locks (unilateral task, affected side)
- Task F (TF): spoon out dry ingredients (unilateral task performed bilaterally, i.e., affected and less affected sides simultaneously).

Each task is standardized but can be modified slightly if necessary. For example, the handle of the spoon in task F could have been enlarged to make it easier to grasp.

3) Task order

In the context of motor learning, the tasks were repeated and done in blocks or in random order. The repetition of tasks in blocks, i.e., repeating the same task several times in succession, seems to improve short-term learning.[47] However, the repetition of tasks in random order, i.e., interspersed with other tasks, is reportedly more effective in learning retention, perhaps because the person has to continually change the sequence of movements, make postural readjustments and use the correct muscle groups while inhibiting the antagonists,[47] which helps to develop the adaptability required in activities of daily living.[48] This improves retention and task generalization.

Thus each task was first performed repeatedly in a block (example: TA, TA, TA). Then the different tasks were performed in random order (TA, TE, TB, TF, TC, TD).

The following example illustrates a 40-min training session using the six tasks described above.

Practice in blocks

Each task was performed three times in succession in five identical series.

TA TA TA TA TA TA TA TA TA TA TA TA TA TA TA
TB TB TB TB TB TB TB TB TB TB TB TB TB TB TB
TC TC TC TC TC TC TC TC TC TC TC TC TC TC TC
TD TD TD TD TD TD TD TD TD TD TD TD TD TD TD
TE TE TE TE TE TE TE TE TE TE TE TE TE TE TE
TF TF TF TF TF TF TF TF TF TF TF TF TF TF TF

Practice in random order

Each task was first performed three times in succession in the following order:

TC TC TC TA TA TA TD TD TD TB TB TB TF TF TF TE TE TE

Then each task was performed once in random order:

TE TF TC TD TA TB
TD TC TB TA TF TE
TA TF TD TE TB TC
TB TC TA TF TD TE
TC TA TF TE TD TB

Each session ended with a task chosen by the participant in order to maintain motivation and encourage participants to use their affected upper limb in their activities in the rehabilitation unit.