Clinical Rehabilitation 2006; **20:** 191–200

Motor relearning programme for stroke patients: a randomized controlled trial

Dora YL Chan Kowloon Hospital, **Chetwyn CH Chan** Department of Rehabilitation Sciences, The Hong Kong Polytechnic University and **Derrick KS Au** Department of Rehabilitation, Kowloon Hospital, Hong Kong

Received 26th July 2004; returned for revisions 5th November 2004; revised manuscript accepted 3rd September 2005.

Objective: To study the efficacy of the motor relearning approach in promoting physical function and task performance for patients after a stroke.
Design: Matched-pair randomized controlled trial.
Setting: An outpatient rehabilitation centre in Hong Kong.
Participants: Fifty-two outpatients with either a thrombotic or haemorrhagic stroke who completed either the study or control group.
Interventions: The patients received 18 2-h sessions in six weeks of either the motor relearning programme or a conventional therapy programme.
Main outcome measures: The Berg Balance Scale, the Timed Up and Go Test, the Functional Independence Measure (FIM), the modified Lawton Instrumental Activities of Daily Living (IADL) test, and the Community Integration Questionnaire.
Results: Patients in the motor relearning group showed significantly better performance on all but the Timed Up and Go Test when compared with the control group ($F(1,150) = 6.34–41.86$, $P \leq 0.015$). The interactions between group and occasion were significant on all five outcome measures, indicating that the rates of change across time between the motor relearning and control groups differed ($F(3,150) = 3.60–33.58$, $P < 0.015$).
Conclusion: The motor relearning programme was found to be effective for enhancing functional recovery of patients who had a stroke. Both 'sequential' and 'function-based' concepts are important in applying the motor relearning approach to the rehabilitation of stroke patients.

Introduction

Outcome studies on the rehabilitation of patients who are stroke survivors reveal that 93% of patients have difficulty walking independently in the community after being discharged from hospital.[1] A review of the postdischarge status of 200 patients in a local rehabilitation hospital found that 69.2% of them were unable to participate in household tasks, 37.6% were housebound, and 70.0% did not travel.[1] Similar results were reported in another study conducted by Sarah and Gill.[2] A high correlation has been found between balance function and the functional recovery of patients.[3–5] Nichols *et al.*[6] further revealed that sitting balance was necessary to perform most self-care activities, such as dressing, transferring and eating, whereas standing balance was necessary for coping with household and outdoor activities.

Address for correspondence: Chetwyn Chan, Applied Cognitive Neuroscience Laboratory, Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong.
e-mail: Chetwyn.Chan@inet.polyu.edu.hk

10.1191/0269215506cr930oa

Different therapeutic approaches have been developed to enhance the functional recovery of patients after stroke. The most common are the neurophysiological approach, which emphasizes facilitation and normalization of motor functions,[7] the orthopaedic approach, which is based on the mobilization and strengthening of the affected and unaffected limbs to increase compensatory functions,[8] and the motor relearning approach, which uses active practise of context-specific motor tasks and feedback to regain the lost motor functions.[9] Pollock *et al.*[10] carried out a systematic review of 11 clinical trials. Of these, four used the motor relearning approach as the intervention.[11–14] The review, however, indicated that this approach was found to be no more effective than other neurophysiological approaches. The authors stressed the need to further investigate the efficacy of this approach by conducting high-quality, randomized, controlled trials and refining the intervention techniques. This study is intended to address this need.

The motor relearning approach was developed based on motor learning theory.[15] Carr and Shepherd[9,11] proposed that training in motor control requires anticipatory actions and ongoing practice. To further enhance relearning, the motor tasks involved are practised within a context that can be task or environment specific. A review of the literature revealed that only a few clinically controlled trial studies on the application of the motor relearning approach have been conducted. The results of these studies suggested that patients tended to have a short hospital stay and high functional independence.[14] Patients also showed a significant increase in gait velocity.[12,13] However, these studies did not provide detailed information on how task-oriented strategies were developed and used.

This study sought to investigate the effect of using a sequential function-based task strategy in a six-week motor relearning programme for improving the balance function and functional performance of a group of poststroke patients. The study used a standardized clinical programme and a randomized, controlled trial design, which was meant to provide high-quality evidence to test the efficacy of the intervention for use in the rehabilitation of poststroke patients.

Methods

Subjects

Patients were recruited from the outpatient centre of a rehabilitation hospital. The inclusion criteria for participation in the study were as follows: (1) patients had to be between 21 and 65 years of age (eligible admission to outpatient setting); (2) they must have been diagnosed as having suffered a first stroke; (3) the stroke must have occurred within the previous 12 months; and (4) patients had to be able to follow simple instructions as screened by the Chinese version of the Cognistat.[16] Patients were excluded from the study if their conditions were complicated by other musculoskeletal injuries and/or visual deficits. Ethics approval was obtained from the hospital and The Hong Kong Polytechnic University before commencing the study.

Written informed consent was obtained from each patient before he or she was screened for participation in the study. Random assignment of patients into the sequential function-based motor relearning group and the conventional therapy (control) group was conducted in two stages. The first stage involved arranging patients into a block of six participants and then forming the six into pairs by matching their age and gender; then, if possible, they were matched according to the level of intensity of physiotherapy and speech therapy received in the hospital. Patients who did not form a best-matched pair were automatically entered into the next block for further matching and randomization (Figure 1). The patients were excluded from the study if their characteristics were not matched by the end of the second round. The second stage involved randomly assigning the two patients in each of the best-matched pairs to either the motor relearning or the control groups by drawing one of two sealed envelopes designating the group membership. The randomization process was carried out by a registration clerk who was not involved in any part of the study. All the clinical outcome assessments were conducted by two occupational therapists who were working in the orthopaedic unit of the same outpatient centre. The assessors were blind to the group membership of the patients they assessed. Training sessions were provided to all raters on administering and scoring each clinical instrument in order to

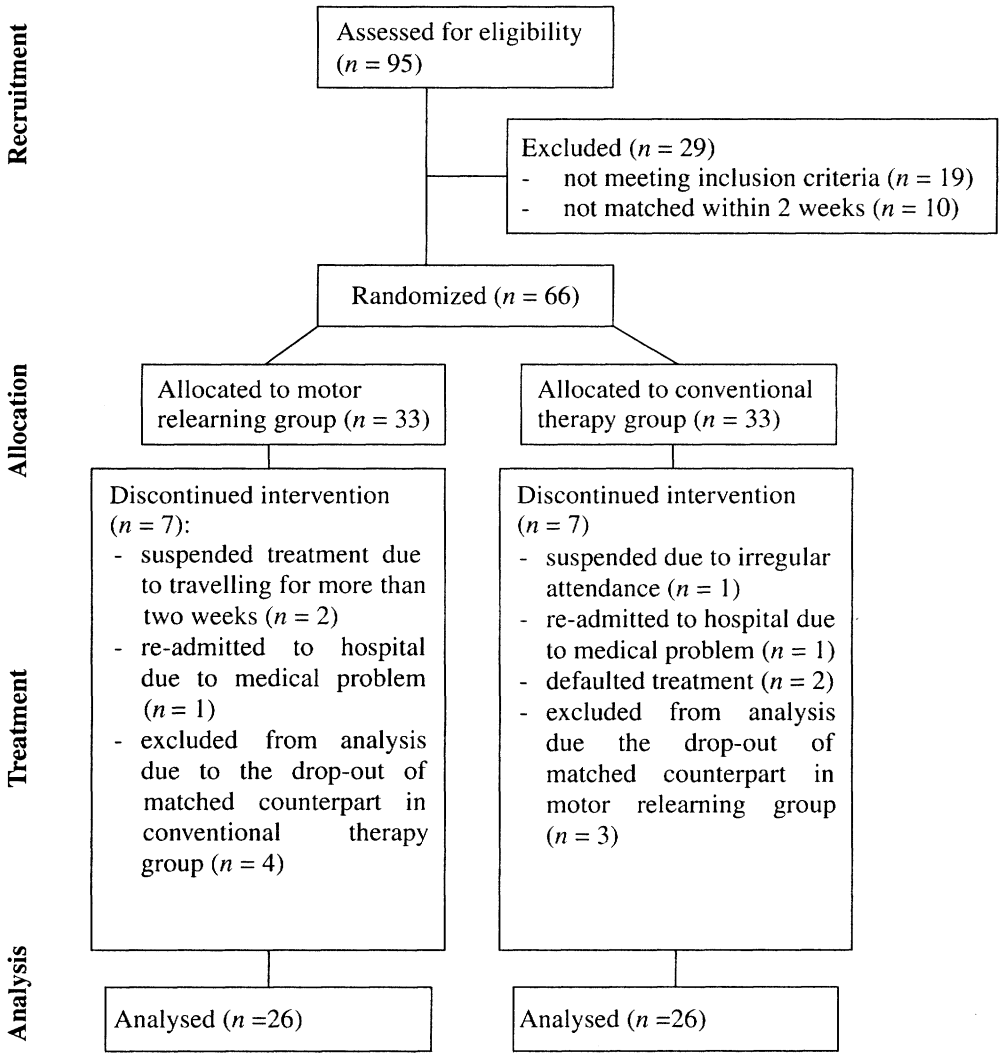

Figure 1 Flow of patient participation through each stage of the study.

minimize any biases associated with the assessment process.

Clinical protocols

In both groups, the patients received training for a total of six weeks in the form of three 2-h sessions each week (18 sessions total). The researcher conducted the motor relearning programme while another occupational therapist conducted the conventional therapy programme. The therapist responsible for the conventional therapy programme was trained in the standardized procedure for conducting the control programme. Both programmes were conducted in the same treatment area located in the occupational therapy department of the hospital. The patients in both programmes also received physical therapy in the form of lower limb strengthening and trunk balance exercises. The patients attended physical therapy from one to three times a week. Their attendance was monitored throughout the study, and the number of sessions was incorporated into the analysis of the results.

Table 1 Examples of the functional tasks covered in the motor relearning and conventional therapy programmes

	Demanding static balance	Demanding dynamic balance
Sitting positions	Feeding Grooming Buttoning Moving bowels	Bed mobility Dressing upper garment Sitting to dress lower garment Cleaning buttocks Sitting to bathe
Standing positions	Grooming Toileting (male) Standing to fasten pant zipper	Bedside transfer Toilet transfer Bathtub transfer Bathing IADL and community activities

In the motor relearning programme, the intervention technique followed four sequential steps: identification of the missing performance components (step 1), training using remedial exercises (step 2), training using functional task components (step 3), and transfer of skills to functional task performance (step 4).[11] A total of 24 remedial tasks (used in step 2) and 10 functional tasks (used in step 4) were designed to cover deficits in static and dynamic sitting balance, and static and dynamic standing balance (refer to Chan[17] for detailed programme design). Table 1 illustrates the relationship of functional tasks to skill deficits. The flow of each 2-h motor relearning session is presented in Table 2. Throughout the training session, the therapist stressed the importance of relating the training processes taking place in steps 2 and 3 to practices in step 4. The training progressed by advancing from a sitting to a standing position, and from static to dynamic balancing. The criteria established for progression were clearly defined, and those patients who demonstrated the desirable skills were upgraded to another stage of training.

The skill training method was adopted for use with patients receiving the conventional therapy programme. The same number of remedial and functional tasks was covered as in the motor relearning programme. The selection of remedial tasks followed the principle of progressing from a sitting to a standing position, and from static to dynamic balance. The training of functional tasks began with simple self-care and bedside tasks, such as bed mobility, and progressed to more complicated tasks, such as use of community facilities. Unlike the motor relearning programme, the

Table 2 Comparisons of the remediation techniques used in motor relearning and conventional therapy programmes

	Outcome measure assessments	
	Motor relearning programme	Conventional therapy programme
Motor relearning (Step 1)	Identify the deficits and missing components in performing tasks, and assign patients to different steps of training	
Motor relearning (Step 2) Duration: 30 min	Select three remedial tasks in each session that are specific to the deficits and missing components identified in step 1 and that share similar performance components with the functional tasks trained in the same session	Select three remedial tasks based on the physical status and progress of the patients. The two functional tasks are selected based on the performance level of the patients
Motor relearning (Step 3) Duration: 30 min	Practise the remedial tasks and reinforce the practice of the missing components throughout the treatment session. Select two functional tasks for training	Task by task practice Practise the remedial tasks without drawing the patient's attention to his/her deficits
Motor relearning (Step 4) Duration: 60 min	Transfer the skills practised in steps 2 and 3 to practice of the functional tasks in accordance with the level of balance function of patient	Practise the functional tasks without explicitly relating the skills learned in the remedial tasks

patients were not involved in identifying their own missing performance components (Table 2). The relationships between the practices of the remedial tasks and the entire functional task performance were not reinforced.

Outcome measures

A total of five common clinical outcome measures were administered to the patients across the six-week programme. The assessment schedule was laid out at baseline (after randomization), two weeks, four weeks, and six weeks. To avoid fatiguing the patients, all assessments were conducted on days when they did not attend the treatment sessions.

The Berg Balance Scale was used to assess the functional balance of patients in terms of maintaining a position, stabilizing voluntary movements and reacting to external disturbances.[18] The Timed Up and Go Test[19] is a measure of the time taken to stand up from a chair, walk for a distance of 3 m, turn, walk back to the chair, and sit down again. This test was found to be relevant for assessing the functional balance of poststroke patients and had implications for their management of outdoor activities.[20] The Functional Independence Measure (FIM) was used to reflect the self-care performance of the patients.[21] In this study, only 13 motor items were administered to the patients (FIM-MM). The Assessment of Instrumental Activities of Daily Living (IADL),[22] modified from the original Lawton IADL scale,[23] was used to assess the performance of more complicated daily living tasks. There were eight items in the scale: taking medication, preparing meals, communicating with others, doing laundry, performing housekeeping, accessing the community, handling finances, and shopping for groceries. These items were evaluated by an expert panel review and were deemed culturally relevant and important to Chinese elderly patients. In addition, the scale used was a more sensitive 7-point Likert scale, which was similar to the one used in the FIM. The results from a pilot study indicated satisfactory inter-rater reliability (ICC = 0.96 to 1.00).[23] Lastly, the Community Integration Questionnaire (CIQ), which consists of 15 items, was used to assess home integration, social integration and productive activity.[24] The Chinese version validated by Chan[25] was used in this study.

Statistical analysis

Two-way repeated-measure ANOVAs were conducted to test the significance of changes in scores on each of the outcome measures between the motor relearning and control groups (2 groups × 4 occasions). A t-test was used to test the differences in number of days after stroke at time of admission between the two groups. The same procedure was used to test the equivalence on the baseline outcome measure scores between the two groups. The significance level of all comparisons was set at $P = 0.050$.

Results

A total of 95 patients satisfied the screening criteria and were recruited for the study. Among them, 66 patients were matched and randomly assigned to either the motor relearning or control groups. Seven patients dropped out for one or more of the following reasons: suspected second stroke ($n = 1$) or gastric ulcer ($n = 1$), irregular attendance ($n = 1$), taking leave to travel out of town ($n = 2$), and default treatment ($n = 2$). The data gathered from their matched-pair counterparts were excluded from the analysis. The mean age of the 52 patients who completed the clinical trial and were included in the analysis was 53.8 years (SD = 15.4) for the motor relearning group and 54.4 years (SD = 13.7) for the control group. There were 28 male participants (54%) and 24

Table 3 Demographic and medical characteristics of patients

Characteristics	Motor relearning ($n = 26$)	Conventional therapy ($n = 26$)
Gender		
Female	14	14
Male	12	12
Hemiplegic side		
Left	14	14
Right	12	12
Poststroke duration (days)	117.7	88.8
Physiotherapy treatment		
Once a week	11	11
Twice a week	9	9
More than twice a week	5	5
No physiotherapy treatment	1	1

Table 4 Means and standard deviations of scores on outcome measures across the four assessment occasions

Measures	Mean (SD)			
	Baseline	2nd Week	4th Week	6th Week
MR group				
BBS	28.2 (8.0)	35.3 (7.7)	41.1 (6.0)	45.8 (3.7)
TUGT	60.5 (22.3)	53.8 (19.9)	47.1 (18.0)	36.4 (15.5)
FIM-MM	61.2 (12.7)	67.5 (10.7)	73.6 (7.6)	80.0 (5.3)
IADL	54.2 (13.1)	62.6 (17.8)	73.3 (13.7)	82.2 (12.1)
CIQ (social)	26.9 (17.7)	43.9 (18.7)	59.5 (18.7)	73.0 (19.9)
CT group				
BBS	27.9 (7.8)	30.0 (10.4)	30.1 (6.9)	37.4 (17.5)
TUGT	62.8 (22.2)	61.8 (21.0)	58.2 (21.3)	58.2 (26.1)
FIM-MM	60.7 (13.2)	62.4 (12.2)	64.1 (11.5)	66.3 (10.5)
IADL	47.4 (14.7)	45.9 (16.6)	50.6 (16.5)	54.4 (19.7)
CIQ (social)	21.5 (16.1)	25.5 (18.0)	31.4 (16.8)	36.3 (17.0)

MR, motor relearning group ($n = 26$); CT, conventional therapy group ($n = 26$); BBS, Berg Balance Scale; TUGT, Timed Up and Go Test; FIM-MM, Functional Independence Measure – Motor subscale; IADL, assessment of instrumental activities of daily living; CIQ (social), Community Integration Questionnaire – Social Integration.

female participants (46%) (Table 3). The same proportion of patients suffered from left and right hemiplegia. The average number of days after stroke at time of admission was 117.7 for the motor relearning group and 88.8 days for the control group, which did not differ significantly ($t = 2.15$, $df = 1$, $P > 0.050$). The majority of the patients received one or two sessions of physiotherapy each week (76.9%). There were no significant differences in the demographic and medical characteristics of the patients between the motor relearning and control groups. Also, no significant differences were found in their scores on the five outcome measures at the baseline (first week) ($P > 0.050$).

There were general increases in the scores on all five outcome measures across the baseline and the second, fourth, and sixth weeks in both the motor relearning and control groups (Table 4). Two-way repeated-measure ANOVAs were conducted on each of the clinical outcome measures (2 groups $\times$ 4 occasions). Significant between-group differences were revealed in scores on the Berg Balance Scale, FIM-MM, IADL and Community Integration Questionnaire ($F(1,150) = 6.34$–41.86, $P \leq 0.015$). The differences in the Timed Up and Go Test, however, were statistically insignificant ($F(3,150) = 2.70$, $P = 0.107$). Significant within-group differences in scores across four assessment occasions were also found on all five outcome measures ($F(3,150) = 28.92$–170.70, $P < 0.001$). The interactions of the group and occasion effects were statistically significant on all five outcome measures, indicating that the rates of change across time between the motor relearning and control groups differed ($F(3,150) = 3.60$–33.58, $P < 0.015$). However, the changes in Community Integration Questionnaire across time were found to be statistically insignificant for the control group (Table 5).

Discussion

The results of this study reveal that patients in the motor relearning group showed better functional recovery than those who were in the conventional therapy group in terms of balance functions, performance on self-care and instrumental activities of daily living, and integration into the community. The six-week motor relearning programme emphasizing sequential and function-based training appeared more effective for enhancing the functional recovery of poststroke patients than the skill-training techniques used in conventional rehabilitation. Nevertheless, the motor relearning programme did not appear to have a significant additional effect on improving the patients' functional balance status in terms of speed and outdoor mobility. Since the patients recruited for this study were on average in the third

to fourth months after their strokes, the findings of the study further support the notion that recovery of function could occur beyond the first three months after the stroke[26–28] and extend to at least six months after the stroke.[12,13,29–31]

Motor learning theory describes the ways in which motor patterns can be acquired and modified through experiential learning, such as through observations and repeated practice.[16] People with a brain injury have deficits in motor programmes, motor memory, and associated feedback and feedforward mechanisms, which largely impede their functional performance.[17] The motor relearning approach promotes the regaining of normal motor skills through task-oriented practice with appropriate feedback and the active participation of the patients.[11] In this study, the motor relearning programme was structured in such a way that patients had ample opportunity to gain this experience. First, the patients were involved in identifying their own problems in performance. These problems are called the missing-performance components. The selection of the remedial tasks used for training was meant to target those missing-performance components. Training in the functional tasks followed through on the same missing components. The incorporation of this strategy turned the programme into a client-centred intervention. The training thus became more anticipatory for the patients[32] and hence was more self-initiated, targeted and effective.[33,34] This is in contrast to the strategy used in the conventional therapy programme, which relied solely on what was identified as dysfunctional from the results of the clinical assessments.

The second feature of the motor relearning programme was the emphasis placed on the transfer of skills between the remedial and functional tasks (steps 2 and 3 in the clinical protocol). The key was having the therapist verbalize the relationship between what was practised in these two steps with the actual performance of daily tasks. For example, when a patient was practising shifting sideways while sitting, the actions were explicitly related to inserting the leg into a trouser leg or putting a foot into a shoe. These skills were further developed as the patient learned to reach down the affected leg to put on socks or shoes. The 'cross-link' method, as reported by Ford *et al.*[34] and Willingham,[35] was effective for facilitating better transfer of the skills learned in training. Similarly, the 'cross-link' strategy was not stressed in the control programme in this study.

Table 5 Results of repeated measure ANOVA between- and within-group comparisons for all outcome measures

Measures (Greenhouse–Geisser)	Baseline	6th Week	*F*-values (*P*-values)	
	Mean (SD)	Mean (SD)	Between-group differences	Within-group differences
BBS				
MR	28.2 (8.0)	45.8 (3.7)	11.37	28.92
CT	27.9 (7.8)	37.4 (17.5)	($P = 0.001$)	($P < 0.001$)
TUGT				
MR	60.5 (22.3)	36.4 (15.5)	2.70	37.19
CT	62.8 (22.2)	58.2 (26.1)	($P = 0.107$)	($P < 0.001$)
FIM-MM				
MR	61.2 (12.7)	80.0 (5.3)	6.34	102.32
CT	60.7 (13.2)	66.3 (10.5)	($P = 0.015$)	($P < 0.001$)
IADL				
MR	54.2 (13.1)	82.2 (12.1)	27.41	35.68
CT	47.4 (14.7)	54.4 (19.7)	($P < 0.001$)	($P < 0.001$)
CIQ (social)				
MR	26.9 (17.7)	73.0 (19.9)	41.86	170.70
CT	21.5 (16.1)	36.3 (17.0)	($P < 0.001$)	($P < 0.001$)

MR, motor relearning group ($n = 26$); CT, conventional therapy group ($n = 26$); BBS, Berg Balance Scale; TUGT, Timed Up and Go Test; FIM-MM, Functional Independence Measure – Motor subscale; IADL, assessment of instrumental activities of daily living; CIQ (social), Community Integration Questionnaire – Social Integration.

Clinical messages

- The motor relearning approach was found to be effective for enhancing patients' functional recovery after stroke.
- Its effects can be maximized by incorporating both 'sequential' and 'function-based' design in the clinical protocol.
- Patients' functional recovery includes motor and balance function, self-care, daily instrumental activities and community (social) reintegration.

The third feature of the motor relearning programme was the sequential organization of the function-based intervention. Both the remedial and functional tasks were organized in the 2×2 grid of functional balance in static versus dynamic mode, and sitting versus standing position. There were a total of 10 functional tasks. Among them, seven were self-care tasks (feeding, dressing, grooming, toileting, transferring, walking, and climbing a slope or stairs), and three were instrumental ADL tasks (doing laundry, taking public transportation and cleaning the floor). The tasks used in the control programme were not sequential; instead, they were selected by the therapist based on the progress of individual patients. The patients in the motor relearning programme were found to perform significantly better on self-care and instrumental ADL tasks, while those in the control programme were found to make comparatively less progress on the latter. Instrumental ADL tasks are complicated in nature, and their performance usually requires higher motor and cognitive functions, as well as generalization of the skills learned.[36,37] In fact, the content of the instruments used for this study reflected, to a certain extent, the abilities of the patients to generalize what they learned in the programme either to novel tasks (other tasks in the IADL measure) or to their own environment (as in the social subscale of the Community Integration Questionnaire). Henceforth, the way in which the tasks are sequenced may enhance the patients' abilities to generalize the skills learned in the programme.[38,39] The two-group design that we used does not allow us to make more a conclusive observation regarding this aspect. Future study should manipulate the different features of the motor relearning programme in order to test each of their effects.

A recent Cochrane review covered four clinical trials of the motor relearning approach. The results of the review indicated that the clinical effects of the motor relearning approach did not differ significantly from other neurophysiological approaches.[10] A close look at these four clinical trials revealed that their techniques lacked either the 'sequential' or 'function-based' component, or both. For instance, in two of the studies,[11,14] the clinical protocols only tackled selected areas of dysfunction, such as reaching in sitting position in one study and stepping in the other study. One study[12] incorporated a sitting, standing and walking training (in sequence); however, the programme did not relate the learned skills to performance of functional daily tasks. Another study[13] did not reveal enough of the programme content detail to comment upon. Lastly, none of the four studies used instrumental activities of daily living as part of the clinical outcomes. In this study, the motor relearning programme was found to exert a significant effect on improving patients' performance in this regard.

Carr and Shepherd's motor relearning programme provides the theoretical foundation for the present study. The findings of this clinical trial reveal that 'sequential' and 'function-based' training are equally important for enhancing patients' functional recovery after stroke. Future design of clinical protocols based on the motor relearning approach should try to incorporate both components to maximize the effects of the intervention.

Limitations of the study

This study has several limitations. The best-matched process used in the randomization might introduce biases into the selection of patients to participate in the study. The dropping out of patients in the motor relearning and control groups would also bias the outcome of the study. Moreover, the patients received other treatment interventions in addition to the motor relearning or control programme, such as physiotherapy and speech therapy, that could contaminate the treatment effects. The patients attended the treatment sessions as day-patients, and their engagement in activities other than those conducted during

treatment possibly further contaminated these effects. Although the assessors were blind to the study, the motor relearning programme was conducted by the researcher, who might have provided more enthusiastic interventions than the therapist who conducted the control programme. The patients who participated in this study were all less than 65 years old. It is anticipated that older patients would have reduced physical and mental abilities and hence might respond differently than would their younger counterparts. Further studies could target poststroke patients 65 years of age or older. This would enable comparisons of the results across different age groups. During the six-week programme, the patients attended three sessions each week. Such a schedule was determined based on the assumption that outpatients would be less inclined to attend more frequent sessions. This limits the generalization of our results to intervention programmes that have a different schedule, such as four times a week or even once a day. Previous studies have reported that the effectiveness of intervention increased with a daily treatment schedule. Future investigations should compare the effectiveness of different treatment schedules as well as the mechanisms underlying the effect.

References

1 Ng HB. Long term outcomes of elderly stroke patients discharged from Kowloon Hospital. Hong Kong Hospital Authority, Hong Kong, 1999.

2 Sarah T, Gill T. Discharge and follow-up for people with stroke: What happens and why. *Clin Rehabil* 2000; **14**: 381–92.

3 Fong NK, Chan CCH, Au DKS. Relationship of motor and cognitive abilities to functional performance in stroke rehabilitation. *Brain Injury* 2001; **15**: 443–53.

4 Lee MY, Wong MK, Tang FT, Cheng PT, Lin PS. Comparison of balance responses and motor patterns during sit-to-stand tasks with functional mobility in stroke patients. *Am J Phys Med Rehabil* 1997; **76**: 401–10.

5 Hsieh CL, Sheu CF, Hsueh IP, Wang CH. Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. *Stroke* 2002; **33**: 2626–30.

6 Nichols DS, Miller L, Colby LA, Pease WS. Sitting balance: Its relation to function in individuals with hemiparesis. *Arch Phys Med Rehabil* 1996; **77**: 865–69.

7 Bobath B. *Adult hemiplegia: evaluation and treatment*. second edition. Butterworth-Heinemann, 1990.

8 Partridge CJ. *Neurological physiotherapy: a problem-solving approach*. Churchill Livingstone, 1996.

9 Carr JH, Shepherd RB. *A motor relearning programme for stroke*. Butterworth–Heinemann Physiotherapy, 1987.

10 Pollock AS, Baer G, Pomeroy V, Langhorne P. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke. *Cochrane Database of Systematic Reviews* 2003; **2**: CD001920.

11 Dean CM, Shepherd RB. Task-related training improves performance of seated reaching tasks after stroke: A randomized controlled trial. *Stroke* 1997; **28**: 722–28.

12 Dean CM, Richards CL, Malouin F. Task-related circuit training improves performance of locomotor tasks in chronic stroke: A randomized controlled pilot trial. *Arch Phys Med Rehabil* 2000; **81**: 409–17.

13 Langhammer B, Stranghelle JK. Bobath or Motor Relearning Programme? A comparison of two different approaches of physiotherapy in stroke rehabilitation: A randomized controlled study. *Clin Rehabil* 2000; **14**: 361–69.

14 Wellmon R, Newton RA. An examination of changes in gait and standing symmetry associated with the practice of weight shifting tasks. *Neurol Rep* 1997; **21**: 54–55.

15 Sabari JS. Motor learning concepts applied to activity-based intervention for adults with hemiplegia. *Am J Occup Ther* 1990; **45**: 523–30.

16 Chan CCH, Lee TMC, Fong KNK, Lee C, Wong V. Cognitive profile for Chinese patient with stroke. *Brain Injury* 2002; 16: 873–84.

17 Chan YL. Efficacy of motor relearning program in improving function after stroke. Master's Dissertation, The Hong Kong Polytechnic University, 2000.

18 Berg KO. Balance and its measure in the elderly: A review. *Physiother Can* 1989; **41**: 240–46.

19 Podsiadlo D, Richardson S. The timed 'up and go': a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991; **39**: 142–48.

20 Hughes C, Osman C, Woods AK. Relationship among performance on stair, ambulation, functional reach, and timed up and go tests in older adults. *Issues Aging* 1998; **21**: 18–22.

21 Granger CV, Hamilton BB, Fieldler RC. Discharge outcome after stroke rehabilitation. *Stroke* 1992; **23**: 978–82.
22 Occupational Therapy Coordination Committee (OTCOC). Hong Kong version of modified Lawton IADL scale. Hong Kong Hospital Authority, Hong Kong, 1998.
23 Lawton MP, Brody EM. Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist* 1969; **9**: 181.
24 Willer B, Rosentbal M, Kreutzer JS, Gordon WA, Rempel R. Assessment of community integration following rehabilitation for traumatic brain injury. *J Head Trauma Rehabil* 1993; **8**: 75–87.
25 Chan MT. Validity of community integration questionnaire in evaluating extent of community integration of individuals with brain injury. Master's Dissertation, The Hong Kong Polytechnic University, 1999.
26 Wade DT, Wood VA, Hewer RL. Recovery after stroke: The first 3 months. *J Neurol Neurosurg Psychiatr* 1985; **48**: 7–13.
27 Duncan PW, Goldstein LB, Matchar D, Divine GW, Feussner J. Measurement of motor recovery after stroke: Outcome assessment and sample size requirements. *Stroke* 1992; **23**: 1084–89.
28 Kelly-Hayes M, Wolf PA, Kase CS, Gresham GE, Kannel WB, D'Aostino RB. Time course of functional recovery after stroke: The Framingham study. *J Neurol Rehabil* 1989; **3**: 65–70.
29 Tangeman P, Banaitis D, Williams A. Rehabilitation for chronic stroke patients: Changes in functional performance. *Arch Phys Med Rehabil* 1997; **71**: 876–80.
30 Yekutiel M, Guttman E. Effectiveness of an intensive outpatient rehabilitation program for postacute stroke patients. *Am J Phys Med Rehabil* 1996; **74**: 114–20.
31 Werner R, Kessler S. Effectiveness of an intensive outpatient rehabilitation program for postacute stroke patients. *Am J Phys Med Rehabil* 1996; **74**: 114–20.
32 Poole JL. Application of motor learning principles in occupational therapy. *Am J Occup Ther* 1991; **45**: 531–637.
33 Liu KPY, Chan CCH, Lee TMC, Li LSW, Hui-Chan CWY. Case reports on self-regulatory learning and generalization for people with brain injury. *Brain Injury* 2002; **16**: 817–24.
34 Ford JK, Smith EM, Weissbein DAI, Gully SM, Salas E. Relationships of goal orientation, metacognitive activity and practice strategies with learning outcomes and transfer. *J Appl Psychol* 1998; **83**: 218–33.
35 Willingham DB. Implicit motor sequence learning is not purely perceptual. *Mem Cognit* 1999; **27**: 561–72.
36 Shea CH, Shebilske WL, Worchel S. *Motor learning and control*. Prentice Hall, 1993.
37 Marley TL, Ezekiel HJ, Lehto NK, Wishart LR, Lee TD. Application of motor learning principles: the physiotherapy client as a problem solver. II. Scheduling practice. *Can J Physiother* 2000; **52**: 315–20.
38 Flinn NA. Clinical Interpretation of 'effect of rehabilitation tasks on organization of movement after stroke'. *Am J Occup Ther* 1999; **53**: 345–47.
39 Canning CG, Shepherd RB, Carr JH, Alison JA, Wade L, White A. A randomized controlled trial of the effects of intensive sit-to-stand training after recent traumatic brain injury on sit-to-stand performance. *Clin Rehabil* 2003; **17**: 355–62.