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The effect of independent practice of motor tasks by stroke patients: a pilot randomized controlled trial

Alexandra S Pollock Department of Physiotherapy, Queen Margaret University College, Edinburgh, **Brian R Durward** Physiotherapy, Podiatry and Radiography, Caledonian University, Glasgow, **Philip J Rowe** Department of Physiotherapy, Queen Margaret University College, Edinburgh and **John P Paul** University of Strathclyde, Glasgow, UK.

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Objective: To investigate the effect of independent practice of sitting balance as an addition to standard physiotherapy treatment for patients with stroke.
Design: Randomized controlled trial, using blocked randomization procedure with 2:1 ratio.
Subjects: Inpatients with diagnosis of stroke, having achieved one minute of independent sitting balance but not yet achieved 10 independent steps, and with no known previous disabilities, pathology or neurological deficit affecting mobility prior to stroke.
Intervention: A four-week regime of independent practice aimed at improving aspects of balance, as an addition to standard physiotherapy treatment based on the Bobath Approach.
Main outcome measure: Proportion of patients achieving 'normal' symmetry of weight distribution during sitting, standing, rising to stand, sitting down, and reaching.
Results: Nineteen subjects were randomized to the control group; nine to the intervention group. There were no clinically significant differences in measured outcome between the groups.
Conclusions: The regime of independent practice had no measured beneficial effect on the balance ability of patients with recently acquired stroke.

Introduction

There are a number of different approaches to physiotherapy for patients with stroke[1–7] all of which lack scientific evaluation.[8] At present there is no experimental evidence to indicate that any one treatment approach is more beneficial at achieving the goals of physiotherapy than any another.[9–11]

The Bobath Approach is the most commonly used physiotherapy approach for the treatment of patients with stroke[8,12–16]; however, the use of the Motor Learning Approach has increased since the 1980s.[12,13] The Motor Learning Approach is based on the assumption that functional activities lost following stroke can be recovered through practice and repetition.[6,7]

Address for correspondence: Alexandra S Pollock, STEP, Academic Section of Geriatric Medicine, 3rd Floor Centre Block, Glasgow Royal Infirmary, Glasgow G4 0SF, UK. e-mail: pollock@middleton4.freeserve.co.uk

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Most physiotherapy approaches for the early stroke patient include an initial aim of treatment related to the improvement of a patient's ability to maintain balance in sitting.[1–7,17,18] Later stage treatment aims include the restoration of balance in standing, and during dynamic activities such as reaching, rising to stand, and sitting down.[3,4,6,7] It is often assumed that recovery of sitting balance is a prerequisite to the restoration of balance during other postures and activities. Hence, this study aimed to implement a regime of independent practice of sitting balance in patients with stroke and to assess changes in balance during a number of different postures and activities.

In summary, the aim of this study was to carry out a pilot randomized controlled trial to investigate the effect on balance of independent practice of sitting balance when applied as an addition to standard physiotherapy treatment.

Methods

The case-series comprised inpatients at the Western General Hospital, Edinburgh, during the period February 1997 to November 1997. Inclusion criteria included the diagnosis of stroke (WHO definition[19]) less than six weeks previously; attending regular physiotherapy sessions; the ability to achieve one minute of independent sitting balance,[20] as assessed by their physiotherapist; unable to achieve 10 independent steps,[20] as assessed by their physiotherapist; no known disabilities, pathology or neurological deficit which affected mobility, prior to the current hospital admission; able to understand the nature of the study and give informed consent. Ethical approval was granted for this study from Lothian Research Ethics Committee.

Patients meeting the inclusion criteria were randomly assigned, using blocked randomization techniques, to either the Standard Physiotherapy Group or to the Independent Practice Group, with a ratio of 2:1. This was achieved using a system of sequentially numbered sealed opaque envelopes. The randomization of patient assignment was carried out in blocks of 12 envelopes comprising eight standard treatments and four independent practice.

Subjects in the Practice Group were invited to attend practice sessions on five days per week, commencing on the day after the baseline measurements of balance and continuing for four weeks. During these practice sessions the regime of independent practice was followed. There was an absence of literature outlining how independent practice to improve balance should be carried out by patients with stroke. Consequently, a regime of practice was specially designed for this study, based – wherever possible – on the evidence and knowledge pertaining to the optimal learning of motor tasks in healthy subjects, and on the results of a series of investigative sessions with volunteer patients. The tasks involved moving a series of simple objects to 'construct' a series of vertical poles, with pegs and rings; and the use of stepped blocks and stacking tasks. The objects to be moved were colour-coded to match guidance lines drawn on the table placed in front of the patient. The use of different colours and shapes allowed careful control over the order of tasks and the angle of reach without necessitating complicated instructions. Simple instruction boards were placed in front on the patient to ensure that the tasks could be carried out independently. Attendance at the practice sessions was encouraged, but was not compulsory. Reasons for nonattendance were refusal (generally due to tiredness) and alternative appointments (e.g. MRI scans, occupational therapy assessments). The median percentage of sessions missed was 20% (10% due to tiredness and 10% due to other appointments). Details of the tasks, equipment, movements required and repetitions can be obtained from the authors on request.

All subjects continued to attend for their standard physiotherapy treatment, which was based on the Bobath Approach. If patients were discharged from hospital no follow-up treatment or measurement was undertaken.

Measurements of outcome

The measurement system[21,22] comprised a standard chair mounted on a small wooden base-box (Figure 1). Placed within the seat of the chair, under the feet, and in the armrests, were a series of force-measurement platforms capable of measuring vertical force. A switch attached to the backrest served to identify whether the subject was in contact with the backrest. The total verti-

Figure 1 The measurement system.

cal force supporting the subject could be calculated using the sum of the forces from all measurement sections, and the distribution of force to the left and right could be determined. Additionally there was a remote hand-held switch for operator-controlled event marking. Data were collected at 50 Hz. Extensive calibration checks indicated that the measurement system was appropriate for the measurement of human movement.[23]

Deficits in balance could manifest as an abnormal alignment of body parts with asymmetry of posture and movement, an inability to adjust to alterations in the centre of gravity, or as an inability to control the body parts during movement.[2–7,24] In order to objectively assess changes in any of these aspects of balance during a number of different postures and movements, the following outcome measures were adopted:

- The mean symmetry of weight distribution during sitting, standing; rising to stand and sitting down. Rising to stand and sitting down were divided into two distinct phases: the seat-on and the seat-off phases.
- The maximum weight transference to the affected and the unaffected side during reaching laterally as far as possible to the affected and unaffected side, from a sitting position, using the unaffected arm to reach with.
- The mean symmetry of weight distribution having achieved a quiet sitting posture, following the movement of reaching out to the affected and unaffected sides.

The testing protocol used standardized instructions and sequencing of tests, however during all movements the movement investigated was what the patient would 'do naturally'. The assessor was not blinded to the group of the patients; but did not see data from any patient until that patient had been discharged from the trial (data were automatically stored on a computer and were not accessed until a patient was discharged).

Data analysis

Based on the data from a sample of healthy subjects ($n = 40$), a 'normal' range of symmetry was defined as any value falling within the range of 90% of the healthy subject data (i.e. between the 5th and 95th percentiles) for each of the

assessed movement tasks. According to the task performed, a mean or peak symmetry index (SI) was calculated for each patient, and the proportion of patients achieving 'normal' weight distribution determined for each task. Patients were categorized as 'unable' if unable to perform a given task independently.

Results

Details of randomization and follow-up are provided in Figure 2. The profiles of the control and practice groups at entry into the trial are detailed in Table 1. The proportion of the control and practice group subjects 'unable' to perform each

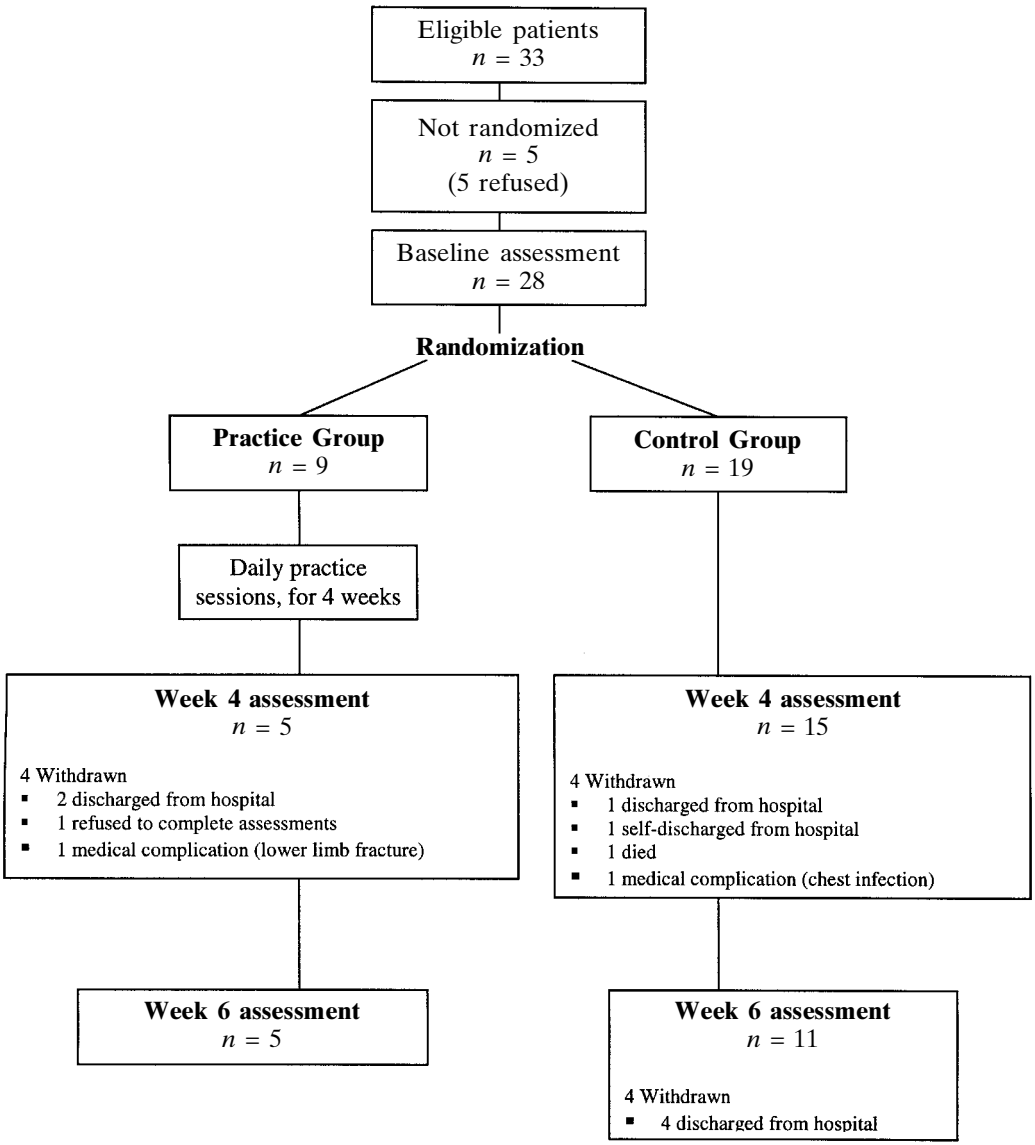

Figure 2 Progress through the trial, including flow of participants, withdrawals and timing of outcome measures.

Table 1 Patient characteristics at entry into trial

	Control group	Practice group
Number of subjects	19 (100%)	9 (100%)
Number of TACIs[a]	6 (32%)	2 (22%)
Number of PACIs[a]	3 (16%)	3 (33%)
Number of LACIs[a]	5 (26%)	4 (44%)
Number of POCIs[a]	2 (11%)	0 (0%)
Number of PICHs[a]	3 (16%)	0 (0%)
Number of left hemiplegics	10 (53%)	7 (78%)
Number of right hemiplegics	9 (47%)	2 (22%)
Number of males	12 (63%)	0 (0%)
Number of females	7 (37%)	9 (100%)
Age, mean years (SD)	68.4 (13.4)	73.1 (10.3)

[a]Stroke classification according to Bamford *et al.*[25]: TACI, total anterior circulation infarct; PACI, partial anterior circulation infarct; LACI, lacunar infarct; POCI, posterior circulation infarct; PICH, primary intracranial haemorrhage.

function, or performing each function with 'normal' symmetry values were determined. The mean and range of the proportion of subjects 'unable' or with 'normal' symmetry values are displayed in Table 2.

There were no significant differences between the two groups on any of the test weeks for the symmetry of weight distribution during sitting, standing, rising to stand, sitting down or reaching ($p > 0.05$). Significantly fewer patients in the practice group than in the control group had 'normal' weight distribution during sitting after reaching to the affected side in week 4 ($p = 0.027$). Exploration of data on this test week indicated that the patients in the practice group tended to distribute more weight on the affected side than patients in the control group.

Although the proportion of patients able to stand, rise to stand and sit down increased over the test weeks, there was no tendency for the proportion of subjects with 'normal' symmetry of weight distribution to change in a particular direction over time, for any of the functions.

Discussion

This study was unable to provide any evidence that demonstrated any measured beneficial effect of the independent practice of sitting balance. With one exception, there were no significant differences in the ability of patients in the practice or control groups to achieve 'normal' weight distribution during any of the measured outcomes. The one exception was that, at the end of the four-week practice period, patients in the practice group demonstrated a tendency to return to a *less* symmetrical sitting position following reaching to the affected side. This difference between the groups was not sustained at the follow-up (week 6) assessment.

The significant difference between the groups for the symmetry of weight distribution during sitting after reaching to the affected side provided some evidence of a change in motor performance. However the clinical implications of this very specific change in motor performance are not known. As the limited change in motor

Clinical messages

- A pilot randomized trial showed no measured beneficial effect for stroke patients when they carried out a practice regime aimed at improving sitting balance, as an addition to standard physiotherapy treatment.
- Despite six weeks of physiotherapy, the ability of patients with stroke to maintain postures and move with 'normal' weight distribution did not increase.

Table 2 Proportion (and percentage) of tests with symmetry within normal outcomes and the *p*-value for the chi-squared test for the difference between the ability of the control and practice group subjects

		Control		Practice		
		Unable	Normal	Unable	Normal	*p*-value
Mean SI during sitting	Baseline	0/57 (0%)	33/57 (58%)	0/27 (0%)	6/27 (22%)	0.077
	Week 4	0/45 (0%)	21/45 (47%)	0/15 (0%)	0/15 (0%)	0.058
	Week 6	0/30 (0%)	12/30 (40%)	0/15 (0%)	6/15 (40%)	1.000
Mean SI during standing	Baseline	51/57 (90%)	3/57 (5%)	21/27 (78%)	3/27 (11%)	0.711
	Week 4	8/45 (18%)	17/45 (38%)	0/15 (0%)	0/15 (0%)	0.085
	Week 6	8/29 (28%)	13/29 (45%)	0/15 (0%)	6/15 (40%)	0.306
Mean SI during seat-on phase of rising to stand	Baseline	54/57 (94%)	0/57 (0%)	24/27 (89%)	3/27 (11%)	0.272
	Week 4	14/45 (31%)	6/45 (13%)	6/15 (40%)	6/15 (40%)	0.266
	Week 6	12/29 (41%)	5/29 (17%)	3/15 (20%)	3/15 (20%)	0.689
Mean SI during seat-off phase of rising to stand	Baseline	54/57 (95%)	3/57 (5%)	24/27 (89%)	0/27 (0%)	0.272
	Week 4	14/45 (31%)	8/43 (19%)	6/15 (40%)	3/15 (20%)	0.918
	Week 6	11/30 (37%)	10/28 (36%)	3/15 (20%)	0/15 (0%)	0.117
Mean SI during seat-off phase of sitting down	Baseline	57/57 (100%)	0/57 (0%)	27/27 (100%)	0/27 (0%)	1.000
	Week 4	16/45 (36%)	6/45 (13%)	6/15 (40%)	0/15 (0%)	0.703
	Week 6	11/30 (37%)	6/28 (18%)	6/15 (40%)	3/15 (20%)	0.979
Mean SI during seat-on phase of sitting down	Baseline	57/57 (100%)	0/57 (0%)	27/27 (100%)	0/27 (0%)	1.000
	Week 4	17/45 (38%)	11/45 (24%)	6/15 (40%)	3/15 (20%)	0.974
	Week 6	11/30 (37%)	10/28 (36%)	6/15 (40%)	6/15 (40%)	0.953
Peak SI during reaching to the unaffected side	Baseline	0/57 (0%)	24/57 (42%)	0/27 (0%)	5/23 (22%)	0.305
	Week 4	0/45 (0%)	33/45 (73%)	0/15 (0%)	6/15 (40%)	0.176
	Week 6	0/30 (0%)	18/30 (60%)	0/15 (0%)	3/15 (20%)	0.143
Peak SI during reaching to the affected side	Baseline	0/57 (0%)	30/57 (53%)	0/27 (0%)	9/27 (33%)	0.339
	Week 4	0/45 (0%)	30/45 (67%)	0/15 (0%)	15/15 (100%)	0.136
	Week 6	0/30 (0%)	21/30 (70%)	0/15 (0%)	12/15 (80%)	0.680
Mean SI during sitting after reaching to the unaffected side	Baseline	0/57 (0%)	27/57 (47%)	0/27 (0%)	12/27 (44%)	0.885
	Week 4	0/45 (0%)	30/45 (67%)	0/15 (0%)	3/15 (20%)	0.069
	Week 6	0/30 (0%)	24/30 (80%)	0/15 (0%)	6/15 (40%)	0.121
Mean SI during sitting after reaching to the affected side	Baseline	0/57 (0%)	21/57 (37%)	0/27 (0%)	15/27 (56%)	0.350
	Week 4	0/45 (0%)	34/45 (75%)	0/15 (0%)	3/15 (20%)	0.027[a]
	Week 6	0/30 (0%)	15/30 (50%)	0/15 (0%)	12/15 (80%)	0.264

[a]Significant difference at 95% confidence level ($p < 0.05$).

NB: At baseline, week 4 and week 6 the number of control subjects tested were 19, 15 and 10 respectively; the number of practice subjects tested were 9, 5 and 5 respectively. Figures presented are based on three repeated tests for each subject, i.e. a total of 57, 45 and 30 tests for the control group and 27, 15 and 15 tests for the practice group on the respective test weeks. Where totals are less than these numbers this is due to missing data.

performance was not sustained during the week 6 assessment ('retention test'), this study provides no evidence of independent practice resulting in a change in motor learning.

No pattern of increased numbers of control or practice group subjects with 'normal' symmetry indices was observed for any of the 10 tasks. A common goal of physiotherapy treatment for stroke patients is the achievement of 'normal' movement, emphasizing 'normal' symmetry of movement and weight distribution during functional tasks. This study was unable to provide any evidence for the successful achievement of this goal during six weeks of physiotherapy treatment. This unexpected finding has fundamental implications for physiotherapists involved in the treatment of stroke patients. If repeated in a larger trial, these results would challenge whether the goals of improving aspects of balance in patients with stroke are appropriate, and whether the treatment techniques used to achieve these goals are successful.

Limitations of study

This pilot study had low numbers of participants, and a relatively high number of withdrawals. The sample included in this study had all attained one minute of independent sitting balance, and therefore may have excluded patients for whom rehabilitation of sitting balance was a key physiotherapy aim. This study concentrated on one very specific measure of force distribution during posture and movement: further outcomes, relating to general functional ability in addition to measures specific to aspects of balance, may have detected changes between the groups.

There was a lack of evidence in the literature pertaining to the specific nature of the tasks to be practised to restore sitting balance, or the number of repetitions of such a task required to effect a permanent change in motor performance. The practice regime adopted in this pilot study was therefore novel and exploratory. In order to standardize the intervention all patients carried out an identical practice regime. However the Motor Learning Approach emphasizes the identification and re-education of specific kinematic components of a movement for each individual subject.[8] It could be argued that the failure to identify and address specific kinematic problems and to provide individualized feedback on performance restricted changes in motor performance and, consequently, motor learning. Furthermore, to avoid contamination between the control and practice groups and to achieve satisfactory methodological rigour the practice sessions took place once per day in a room removed from the ward environment, rather than taking place throughout the day within the ward environment, as may have been preferable for motor learning. Thus, although the study design may have been scientifically rigorous, the intervention studied may not have met with the criteria for optimal motor learning.

Due to limited resources this study did not use a blinded assessor, and patients in the control group did not receive any 'placebo' intervention. A further source of potential bias could have been the failure to blind members of the clinical rehabilitation team (nurses, physiotherapists, etc.) to the treatment group allocation of patients. Observations made during this study suggest that the regime of independent practice was viewed, by both rehabilitation staff and patients, as 'additional' while the standard physiotherapy sessions were generally viewed as a more compulsory part of the daily routine. Larger scale studies should control for these potential sources of bias.

The measurement system used in this study collected data from a number of different force sections. However the symmetry index used in data analysis combined the force measurements from the different sections into 'left' and 'right'. Potentially valuable and interesting data may have been obtained from the different force sections: future data analysis should evaluate the symmetry of force distribution across the various sections of the measurement system.

Conclusions

This pilot randomized controlled trial demonstrated no clinically significant differences between patients who were or were not invited to attend independent practice sessions aimed at improving sitting balance.

However, a surprising finding of this study was

that, despite six weeks of physiotherapy treatment, the ability of patients with stroke to sit, stand, rise to stand and sit down with 'normal' weight distribution, and the ability to transfer weight on to one side during reaching, did not increase and was not altered by additional independent practice. This lack of measured change in balance ability, of patients in either treatment group, has fundamental implications for physiotherapy treatment for patients with recently acquired stroke. Further research is required to investigate this unexpected result.

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