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An exploratory randomized controlled trial of assisted practice for improving sit-to-stand in stroke patients in the hospital setting

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Objectives: To evaluate the amount of practice achieved and assess potential for effects on performance of 30 minutes of daily training in sit-to-stand.
Design: Randomized controlled pilot study.
Setting: Stroke rehabilitation unit, UK.
Participants: Eighteen stroke patients needing 'stand by' help to sit-to-stand.
Interventions: In addition to usual rehabilitation the experimental group ($n = 9$) practised sit-to-stand and leg strengthening exercises for 30 minutes, on weekdays for two weeks, with a physiotherapy assistant. The control group received arm therapy.
Main outcome measures: Frequency of sit-to-stands per day. Performance measures: rise time, weight taken through the affected foot at 'thighs off', number of attempts needed to achieve three successful sit-to-stands and the number of sit-to-stands performed in 60 seconds. Outcome was measured one and two weeks after baseline assessment.
Results: Sit-to-stand frequency averaged 18 per day. Thirty minutes of practice in sit-to-stand resulted in a mean of 50 (SD 17.2) extra stands per day. There was a significant mean difference of 10% body weight taken through the affected foot after one week of intervention: The control group had reduced weight through the affected leg while the training group increased weight ($F_{1,16} = 11.1$, $P = 0.004$, 95% confidence interval (CI) −16.61 to −3.72). No significant differences between groups were found on other measures. Results two weeks after baseline were inconclusive due to loss of five participants.
Conclusions: Task-specific practice given for 30 minutes a day appears promising for patients learning to sit-to-stand.

Introduction

Rehabilitation involves learning new skills or relearning old ones. Skill learning requires considerable practice[1] and repetition of task-specific activities used in stroke rehabilitation has been shown to improve performance of upper limb tasks and walking ability.[2,3] A recent meta-analysis of studies of augmented exercise therapy showed that at least 16 hours of therapy time above the standard services was needed to make a difference to independence in activities of

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daily living.[4] Yet, there are significant organizational and financial barriers to the provision of adequate practice and motor skill learning in rehabilitation services in hospitals. In the UK the amount of time spent with a therapist is meager, typically only about 45–60 minutes each weekday.[5] This short time is used to cover all aspects of rehabilitation and is not solely focused on practice of one or two functional tasks. Given the increased prevalence of stroke and the economic and social cost of disability, we urgently need to explore new models of care that can increase practice of functional tasks safely but economically. One possible solution may be to provide a trained helper. While a qualified therapist should determine appropriate training strategies, a helper can provide support and encouragement, and give feedback about performance, as well as ensuring that the equipment and the patient's manoeuvres remain safe.

The ability to stand safely is an important prerequisite for mobility and independence in self-care[6] and for prevention of falls.[7] Learning to stand up after a stroke is commonly compromised through weakness and poor postural stability but improvements in balance and sit-to-stand performance have been obtained in community-based studies where stroke patients have been given task-specific practice for three to four weeks.[7–9] Beneficial effects have also resulted from a hospital-based practice scheme delivered over several weeks: the number of patients achieving independent sit-to-stand was higher in a group who were given extra practice over 5–10 weeks than in a control group who received standard care in a Canadian hospital.[10]

Short lengths of stay are typical in the NHS in the UK.[11] The purpose of this pilot trial was to assess the amount of practice that could be delivered by a physiotherapy assistant in 30 minutes a day, over a two-week period in a busy UK stroke rehabilitation unit and to assess the potential value of the practice scheme for improving performance of sit-to-stand.

Methods

Participants

Hemiparetic stroke patients were recruited from the stroke rehabilitation wards at North Bristol NHS Trust. Inclusion criteria were: (1) The ability to sit-to-stand but needing 'stand by' supervision to rise without using hands for support. (2) Unable to perform the task more than three times in 10 seconds (as described in the Motor Assessment Scale[12]). (3) To maintain relevance for those allocated to the control group, who received arm therapy, all patients had to have impaired upper limb function due to the stroke.

Patients were excluded if they were in a confused state, unable to give informed consent, medically unfit for the training or if they had been unable to sit-to-stand independently prior to stroke. Cognitive and sensory deficits did not preclude entry to the study, but the presence of any such factors was noted since they were likely to hinder learning to sit-to-stand.[13]

All the procedures were performed in accordance with a protocol approved by the Local Research Ethics Committee.

Intervention

A specialist physiotherapist (LB) assessed each participant's sit-to-stand performance, to identify problem components and prescribe appropriate practice strategies. Since participants were all able to stand (but were slow and unsteady), they were all prescribed whole task practice of sit-to-stand without using their arms for support. The emphasis was on improving technique: foot placement at the start of movement, speed – especially in forward movement of the trunk, and increasing weight-bearing through the affected leg to generate symmetrical ground reaction forces at thighs off. A balance performance monitor was used specifically to give visual feedback to patients who were considered to have asymmetry in weight-bearing when rising. A physiotherapy assistant supervised the practice. The assistant gave instruction and verbal feedback to aid learning. Practice was varied by changing the seat height and surfaces from which to stand.

The aim of the half hour session was to maximize the number of sit-to-stand repetitions, but when the participant fatigued strengthening exercises were carried for any remaining time. These were concentric actions specific to the muscle groups and range of movement used in sit-to-stand. The lower limb extensor muscles were targeted for their role in the extension phase of sit-to-stand. Other muscle groups were included if these were identified as a specific problem, for example hip flexors and ankle dorsiflexors (used in the pre-extension phase).

The practice was carried out for 30 minutes a day and was in addition to routine physiotherapy and occupational therapy. None of the patients were asked to practise outside of these sessions. The physiotherapy assistant kept a log of the training times for use in later analysis of the frequency of sit-to-stands.

Evaluation

A randomized controlled trial design was used. Participants were assigned to a sit-to-stand practice group or to a control group. The control group received sedentary arm therapy that consisted of arm or hand training tasks and/or stretch positioning for 30 minutes. This control intervention served as an attention control and was in addition to the routine rehabilitation programme. It was selected as having a perceived value to patients considering participation in the study, but was considered unlikely to affect sit-to-stand performance as measured in the evaluation. Group allocation was revealed after the baseline assessment, by reference to a pseudo random sequence of 20 allocations that controlled for a balance of numbers between groups. The sequence was drawn up, before the beginning of the trial, by putting 20 tickets into a paper bag; ten tickets had 'experimental' and ten 'control' written on them. A person who was independent of the study pulled the tickets blindly, one at a time, from the bag. The resulting sequence was held by a secretary who was unaware of any features about the patient when asked for the group allocation of participants.

Outcome measures

The number of sit-to-stands performed each day was recorded using an ActivPal single axis accelerometry activity monitor (Pal Technologies, Glasgow). The validity of ActivPal counts of sit-to-stand transitions in stroke patients has previously been reported as having good agreement with counting by direct observation.[14] The monitor was worn on the front of the thigh, inside a pocket sewn into a 'tubigrip' cuff. The participant wore it for most of the 'therapy' day (modal time of use 10 am–3 pm). The monitor was switched off and then on again at the start and end of training sessions to separate sit-to-stands carried out during the practice scheme from the activity of the rest of the therapy day. Data stored in the ActivPal were downloaded to a computer each day and were automatically processed using a minimum movement time of two seconds. Participants in both groups wore the activity monitors.

The biomechanics of sit-to-stand are well described in the literature and therefore measurement of performance is relatively easy to operationalize (see refs 15 and 16). Normal subjects perform the action quickly and exhibit a virtually symmetrical weight distribution.[17,18] These kinematic performance measures were used to assess the performance of sit-to-stand in this study. As patients developed skill in sit-to-stand it was expected that they would rise in less time and have more symmetry in weight-bearing during the course of the movement.[19–20] It was also expected that they would become more successful in their attempts to stand and that they would have increased endurance to perform repeated sit-to-stands. To detect these changes in performance the following measures were taken at baseline and at one and two weeks after baseline:

1) Mean rise time from three single discrete sit-to-stands.
2) Mean peak body weight over the affected foot at end of rise (i.e. after thighs-off but before stabilization phase) calculated from three single discrete sit-to-stands.
3) Number of attempts to perform three successful sit-to-stand movements.
4) Number of sit-to-stands in 1 minute.

Measurement procedure

Participants were seated on an adjustable height plinth set to 110% or 120% of lower leg length depending on ability to stand without physical assistance. The seat height used was maintained for individuals over all of their assessments. The weight taken through right and left feet was measured using a 44×48 cm pressure-sensitive mat (TEKSCAN HR) with 8352 elements sampled at 60 frames per second. The system was calibrated to the individual's body weight in kilograms at the first measurement session. The participant's feet were bare and he or she determined foot position within the boundaries of the mat. The participant was asked to keep hands clasped in front and to stand up as quickly and as well as possible. This was done first for a practice trial and then repeatedly for up to six times or until three successful attempts had been recorded. There was at least 1 minute of rest between each trial.

After recording these discrete sit-to-stand trials, the mat was removed, and the participant was asked to sit-to-stand as many times as possible in 60 seconds, making sure that balance was achieved in standing before sitting each time.

Other clinical information

Since soft tissue and joint stiffness at the ankle on the affected side can prevent the foot being positioned optimally for bearing weight in sit-to-stand and affects the potential for rising independently,[13,15,16,21] passive resistance to dorsiflexion was measured at baseline. This was done with the participant lying supine and with the lower limb supported on a stool below the knee, but leaving the ankle unsupported and free to move. A metal plate with a spring balance attached was strapped to the sole of the participant's foot. The relaxed ankle was pulled into 90° of dorsiflexion and the force read from the spring balance. Both ankles were measured and the stiffness of the affected side was expressed as a percentage of the unaffected side.

Kinematic analysis

Rise time and peak body weights were extracted from force time profiles of the pressure mat recordings. Using the force time profile resulting from the whole area of the mat, rise time was determined as the interval between the first deflection from baseline to the peak pressure before the force plateaued (see Figure 1a). This rise time is a conservative estimate of movement time since it excludes any movement before foot pressure changes (i.e. the earliest part of the movement) and the stabilization time at the end of the movement. Having found the time of peak pressure at end of rise, but before stabilization in standing, the peak body weight in kilograms, over the affected foot was extracted (Figure 1b). This was expressed as a percentage of total body weight.

The assessor was not blind to the group allocation, however the outcomes selected minimized value judgements and instructions and recording procedures were standardized as much as possible.

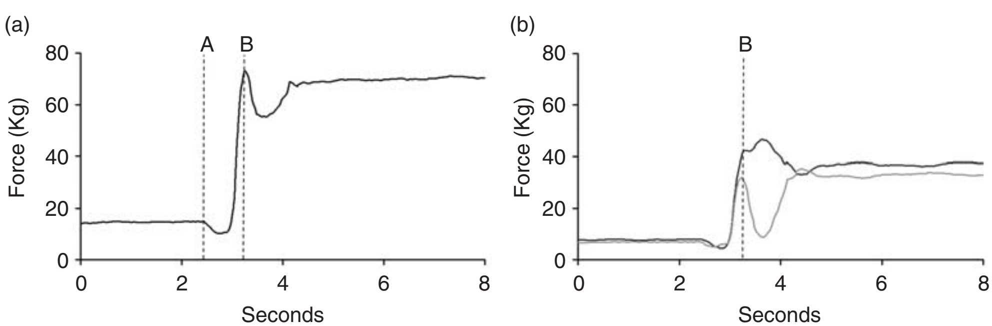

Figure 1 Measurements taken from force–time profiles resulting from pressure mat recording of sit-to-stand. (a) Force–time profile of sit-to-stand summed from both feet. Rise time is interval AB, in this example 1.1 seconds. (b) Force–time profile of sit-to-stand, through left (dark trace) and right (lighter grey trace) foot. Moment of peak force is indicated by dashed line B on the plot. In this example: weight through the left foot is 41.2 kg, right is 31.9 kg.

To establish reliability of the kinematic analysis, a second assessor independently checked a sample of 35 measurements.

Analysis of results

Daily frequency of sit-to-stands was extracted from the ActivPal data files. Training logs were used to confirm which files related to the practice sessions. Frequency of sit-to-stand within the training sessions was compared to the total counts for the rest of the day.

For each measurement session, mean rise times and mean peak percentage body weight through the affected leg was calculated from the first three successful sit-to-stands (excluding the practice trial). Inter-rater reliability of pressure mat measures was assessed using Pearson's correlation coefficients, mean differences and 95% limits of agreement between raters.

The effectiveness of sit-to-stand training was assessed using repeated measures analysis of variance (factor 1: assessment session, factor 2: group) with SPSS software, version 12.0.1. Differences in measures between the baseline and outcome at week one were calculated for each participant. These differences between groups were tested with independent samples *t*-tests to determine confidence intervals of the effects of sit-to-stand training. The significance level for all tests was set to 95%, $P = 0.05$.

Results

One hundred and ninety hemiparetic stroke patients were screened for entry to the study. One hundred and sixty-five were excluded because they did not fit the criteria. Seven were excluded because it was expected that they would be discharged within the week. Eighteen patients were recruited; their flow through the study is shown in Figure 2. Patients met the inclusion criteria relatively late in their hospital stay, when discharge was imminent. In the more severely affected patients this status took over two months to achieve.

Nine participants were allocated to the experimental group and nine to the control group. Only eight experimental group and five control group patients were available for assessment two weeks after baseline. Two were discharged before completion and three were unable to continue due staff shortages. Because this was a small study, intention-to-treat analysis was not applied and only outcomes at one week were subjected to statistical analysis.

The characteristics of the participants and sit-to-stand performance at baseline are listed in Table 1. Both groups had a ratio of seven men to two women. The mean age and time since stroke were substantially less for the control group than the experimental group. The groups were well balanced in terms of sit-to-stand performance and the amount of ankle stiffness. Left hemiparesis was predominant in the experimental group while the control group had a more even distribution of left- and right-sided weakness. These differences would suggest that the groups were not equivalent for the prevalence and severity of cognitive or sensory impairments that may affect the outcome of training. Cognitive or sensory impairments were not specifically measured for this study but examination of the medical notes indicated that both groups included patients with impaired sensation, memory and attention and one participant had aphasia.

Amount of sit-to-stand practice attained

The mean frequency of sit-to-stands per day, derived from the activity monitors over the first five days of training is shown in Table 2. Due to technical problems records were not complete for five days; therefore mean frequency of sit-to-stand was determined from the days when a full record of the 'therapy' day was achieved. Mean frequency of sit-to-stand in the control group was 18.6 (SD 8.4). This was similar to the number of stands performed outside of the training session for the experimental group. Giving 30 minutes of practice in sit-to-stand resulted in a mean of 50 (SD 17.2) extra stands per day, an increase of 269%.

Inter-rater reliability of pressure mat measurements

Correlations were high between raters ($r = 0.95$) for the determination of weight taken through the affected foot and the rise time ($r = 0.86$). Mean differences (95% limits of agreement) were 0.53 kg (−3.14 to 4.19 kg) and 0.08 seconds (−0.63 to 0.48 seconds) respectively.

Effects of practice

Results are illustrated in Figure 3. Rise time decreased significantly for both groups with assessment session ($F_{1,16} = 9.1$, $P = 0.008$), but

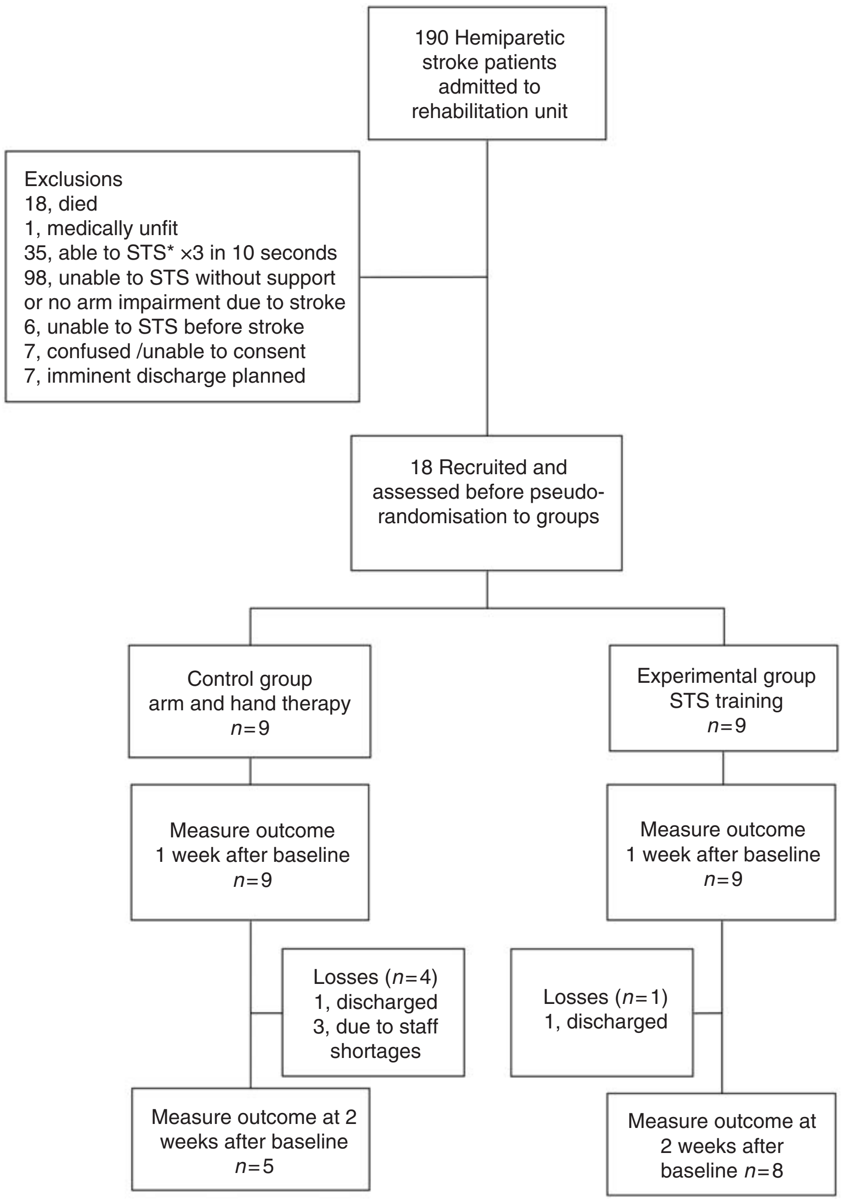

Figure 2 Trial design and participants' progress through the study. Nine experimental and nine control subjects were recruited and assessed one week post baseline. After that four patients were lost from the control group and one from the experimental group. STS, sit-to-stand.

there was no interaction between group and assessment session. There was a significant interaction between group and assessment session on percentage of body weight taken through the affected leg: The control group had reduced weight through the affected leg at the one week assessment while the training group increased weight ($F_{1,16} = 11.1$, $P = 0.004$, see Figure 3b). There was no significant difference in the number of attempts needed to produce three successful sit-to-stands over the two assessments and no interaction. The number of sit-to-stands in 1 minute increased with assessment session ($F_{1,16} = 26.9$, $P < 0.001$) but there was no interaction with group. Mean differences and 95% confidence intervals derived from independent samples *t*-tests are reported in Table 3.

Table 1 Participant's characteristics and baseline performance measurements

	Experimental group ($n = 9$)	Control group ($n = 9$)
Characteristics		
Male:female	7:2	7:2
Mean (SD) age, years	68.4 (13.3)	63.0 (10.6)
Side of hemiparesis (left:right)	8:1	5:4
Mean (SD) days post stroke	50.8 (35.2)	40.2 (32.1)
Ankle stiffness (affected/unaffected side expressed as a percentage)	119 (20)	113 (18)
Mean (SD) Baseline measurements		
Rise time (seconds)	1.59 (0.70)	1.59 (0.65)
% Body weight through affected foot	38 (6.8)	39 (6.2)
No. of attempts to achieve three sit-to-stands	5 (1.6)	4 (1.1)
Number of sit-to-stands in 60 seconds	9.7 (4.7)	8.1 (3.1)

Discussion

This study set in a stroke rehabilitation unit in the UK shows that patients generally received very little sit-to-stand practice each day, standing on average no more than 18 times. Providing just 30 minutes of practice in sit-to-stand resulted in a mean of 50 stands per day that were extra to the normal rehabilitation routine.

Activity recordings were important in providing accurate frequency of sit-to-stands over the therapy day and were important for determining the intensity of additional training. Previous studies designed to test the effects of extra therapy have usually reported the duration of additional training (see ref. 4), which may not relate well to the amount of practice of any one task. It is rare for intensity to be measured directly and related to the amount of activity achieved over the rest of the day (for an exception see ref. 10). In this study sit-to-stand activity was recorded over the 'therapy day'. It is acknowledged that personal care involving standing outside of this time was not captured, however on occasions where the monitor was left on for longer the recordings demonstrated that little additional sit-to-stand activity occurred.

One week of training is a very short intervention; the drop-out rate after one week and observation of patient retention in a previous pilot, has shown that long periods of mobility practice were unworkable in this UK inpatient setting. However, in this small sample, five

Table 2 Mean frequency of sit-to-stands per therapy day

Subject	Days with complete ActivPal records (out of 5)	Sit-to-stands recorded in 1 day	Sit-to-stands in training session	Sit-to-stands recorded out of training session
Experimental group	2.8 (1.1)	65.9 (17.8)	50.1 (17.2)	15.8 (4.7)
Control group subjects	3.8 (1.3)	18.6 (8.4)		

Values are mean (SD).

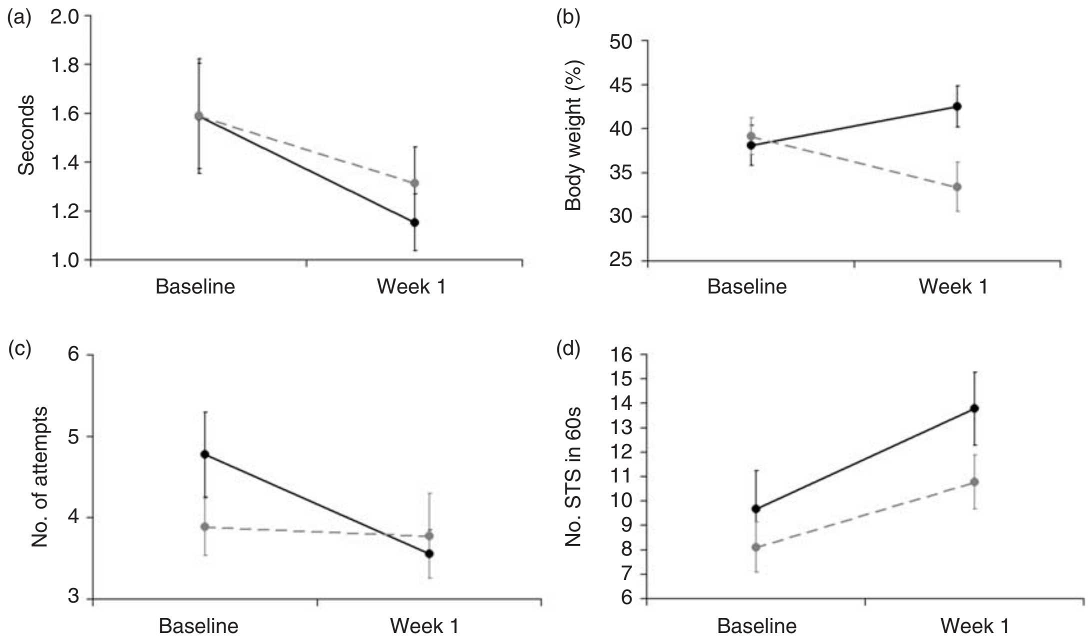

Figure 3 Plots showing mean performance of sit-to-stand at baseline and at one week after baseline for $n = 9$ experimental group (in black) and $n = 9$ control group (in grey). (a) Rise time, (b) peak percentage body weight through the paretic foot, (c) number of attempts to achieve three successful sit-to-stand, (d) number of sit-to-stand in 60 seconds. Error bars represent standard error. Difference between groups in peak percentage body weight through the affected foot during sit-to-stand at one week was significant, $P = 0.004$. There were no significant differences between groups in the other measures.

Table 3 Mean (SD) at baseline and at week 1, mean (SD) of differences in outcome measures between assessments within groups and effect sizes plus 95% confidence intervals (CI) between groups

Outcome	Scores				Mean (SD) differences within groups		Mean (95% CI) differences between groups
	Baseline		Week 1		Week 1–baseline		Week 1–baseline
	Con ($n = 9$)	Exp ($n = 9$)	Con ($n = 9$)	Exp ($n = 9$)	Con ($n = 9$)	Exp ($n = 9$)	Exp–con
Time to stand from force profile (seconds)	1.6 (0.7)	1.6 (0.7)	1.3 (0.4)	1.2 (0.3)	−0.3 (0.4)	−0.4 (0.6)	0.16 (−0.34 to 0.66)
% weight through affected foot at thighs-off	39.2 (6.2)	38.1 (6.8)	33.4 (8.4)	42.5 (6.9)	−5.8 (6.9)	4.4 (6.0)	−10.17* (−16.61 to −3.72)
No. of attempts needed for three successful sit-to-stands	3.9 (1.1)	4.8 (1.6)	3.8 (1.6)	3.6 (0.9)	−0.1 (2.0)	−1.2 (2.0)	1.11 (−0.89 to 3.12)
No. sit-to-stands in 1 minute	8.1 (3.1)	9.7 (4.7)	10.8 (3.3)	13.8 (4.5)	2.7 (2.1)	4.1 (3.3)	−1.44 (−4.25 to 1.36)

Con, control group; exp, experimental group.
*Significant, $P = 0.004$.

sessions of supervised practice was enough to make a positive difference in load-bearing on the affected limb in sit-to-stand. The improvement in the experimental group and the deterioration in the control group sum to a mean difference between groups of 10% of body weight being taken through the affected leg. The amount of difference deemed to be clinically significant was not predetermined in planning this trial. However considering that if the foot is in contact with the ground then the minimum percentage body weight recorded through that foot will be the weight of the leg; estimated at 16% of body weight,[22] and given the target of equal body weight through each foot (i.e. 50%), then 10% is a substantial proportion of the available 34% (50–16%) range in additional body weight to achieve symmetry. We would therefore argue that this represents a substantial clinically significant difference between groups after just one week of training. Although the amount of weight taken through the affected leg is a performance measure rather than an indication of ability it is an important consideration. Difficulty in standing up has been implicated as a cause of falling after stroke[23,24] and increased weight taken through the affected foot during sit-to-stand has been associated with a reduction in falls.[7]

Our activity recordings show that participants in the control group stood up between 6 and 33 times per day in the first week. It seems that they learned to stand up by taking a little more weight on the unaffected side and this was not corrected through the standard therapy delivered over the week. In fact when sit-to-stand is not the specific focus of training, seat height is often not optimal for patients' height or strength and patients are often encouraged or allowed to push on the chair arm with their unaffected hand (personal observations). Patients therefore have little, if any, opportunity to learn to stand with more even weight distribution.

The percentage of body weight taken through the affected foot was the only dependent variable to show a difference between groups in our sample of patients. The fact that the rise time decreased and number of sit-to-stand in 1 minute increased for both groups indicates that patients can become quicker even if, as in the control group's case, they are performing sit-to-stand with more asymmetry. Choosing performance measures for evaluation studies is a challenge. The kinematic performance measures derived from the pressure mat recordings were sensitive to change and showed good inter-rater reliability and were objective, which was important given that the assessor could not be blind to the participants' group. If we had had a longer period over which to deliver the intervention, it would have been appropriate to recruit patients who unable to sit-to-stand at all, without help, and to assess the number who achieved independent sit-to-stand[10] and also to assess whether benefit would generalize to more wide spread functional movements such as improved gait.[9]

Like other small studies of sit-to-stand training after stroke,[7–10] the results of this study suggest that intensive practice shows promise for enhancing the acquisition of functional mobility tasks in stroke rehabilitation. Larger trials of intensive augmented exercise therapy have shown a beneficial effect on walking ability and activities of daily living.[4,25] The recent CERISE project observed lower durations of therapy per day and poorer recovery of motor function in patients in UK stroke rehabilitation units than in three other centres in Europe.[5,26] Patients in the UK centre spent longer doing nothing by their beds while their therapists spent more time doing administration than in the other centres.[5,27] If the sit-to-stand frequencies in our standard care rehabilitation programme and the activity results of the UK centre participating in the CERISE project are assumed to be typical of the stroke rehabilitation services in the UK, then there is clearly a need to increase opportunity for patients to practise functional movements. Physiotherapists in UK stroke units have successfully delivered extra therapy in the context of clinical trials in recent years[28,29] but the challenge for rehabilitation services is to find ways to give patients more opportunity to practise without increasing the pressure on the already stretched therapists. The sit-to-stand programme tested in this study was successfully delivered by a physiotherapy assistant and following the conclusion of this study, extra sit-to-stand practice continues to be delivered by the now expert, in sit-to-stand, physiotherapy assistant.

Clinical messages

- Little sit-to-stand practice is achieved in the standard therapy day in a UK inpatient stroke rehabilitation service.
- Thirty minutes of extra practice supervised by a physiotherapy assistant can more than double the daily frequency of sit-to-stand.
- One week of extra practice can improve sit-to-stand performance in patients who are able to stand but who are unsteady.

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Competing interests

None – The Physiotherapy Research Foundation had no influence over the analysis, interpretation or reporting of the data.

Contributors

LB prescribed the sit-to-stand training for the physiotherapy assistants to practice with patients. NH selected and advised on the activity monitoring and measurement tools. AT performed the analysis and interpretation of the data. All authors contributed to the conception and design of the study and the writing of the paper. AT will be guarantor.

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