

Sitting training early after stroke improves sitting ability and quality and carries over to standing up but not to walking: a randomised controlled trial

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Question: What is the effect of a sitting training protocol in people early after stroke on sitting ability and quality, and does it carry over to mobility? **Design:** Randomised placebo-controlled trial with concealed allocation, assessor blinding and intention-to-treat analysis. **Participants:** Twelve individuals who had a stroke less than three months previously and were able to sit unsupported. **Intervention:** The experimental group completed a 2-week sitting training protocol that involved practising reaching tasks beyond arm's length. The control group completed a 2-week sham sitting training protocol that involved practising cognitive-manipulative tasks within arm's length. **Outcome measures:** The primary outcome was sitting ability (maximum reach distance). Secondary outcomes were sitting quality (reach movement time and peak vertical force through affected foot during reaching) and carry over to mobility (peak vertical force through affected foot during standing up and walking speed during 10 m Walk Test). Outcome measures were taken before and after training and six months later. **Results:** After 2 weeks' training, the experimental group had increased their maximum reach distance by 0.17 m (95% CI 0.12 to 0.21), decreased their movement time by 0.5 s (95% CI -0.8 to -0.2), increased their peak vertical force through the affected foot during reaching by 13% of body weight (95% CI 6 to 20) and increased their peak vertical force through the affected foot during standing up by 21% of body weight (95% CI 14 to 28) compared with the control group. After 6 months, significant between-group differences were maintained for maximum reach distance and peak vertical force through the affected foot during standing up. **Conclusions:** The sitting training protocol was both feasible and effective in improving sitting and standing up early after stroke and somewhat effective six months later. [Dean CM, Channon EF, Hall JM (2007) Sitting training early after stroke improves sitting ability and quality and carries over to standing up but not to walking: a randomised controlled trial. *Australian Journal of Physiotherapy* 53: 97–102]

Key words: Stroke, Posture, Rehabilitation, Disability, Clinical Trial, Hemiplegia, Physiotherapy

Introduction

Sitting involves not only the ability to maintain the seated posture, but also the ability to reach for a variety of objects located both within and beyond arm's length (Dean and Shepherd 1997). Poor sitting ability is a common problem after stroke (Dean and Mackey 1992, Morgan 1994, Harley et al 2006). Recovery of sitting after stroke is important for individuals because sitting is a skill that is critical to independent living (Dean et al 1998, Dean et al 1999a, 1999b). Furthermore, sitting ability has been shown to be a useful prognostic indicator of outcome for this population (Loewen and Anderson 1990, Morgan 1994, Sandin and Smith 1990, van de Port et al 2006).

The disability associated with poor sitting arises primarily because of muscle weakness and loss of dexterity and also because of the tendency to adapt behavior to avoid threats to balance. In particular, it has been shown that in comparison to healthy individuals, individuals after stroke are slower and do not load their affected foot or activate muscles of the affected leg sufficiently when reaching beyond arm's length in sitting (Dean and Shepherd 1997).

Intervention to train sitting is a common focus of rehabilitation after stroke. Previous work has demonstrated the efficacy of a sitting training protocol in individuals who had suffered a stroke 2–17 years previously (Dean

and Shepherd 1997). Dean and Shepherd (1997) found that individuals who were trained specifically to improve their sitting by focusing on appropriate loading of the affected foot were able to reach further and faster. In addition, these individuals were able to increase the load taken through the affected foot and increased the consistency of activation of muscles in the affected leg. Carry over to standing up was also reported. However, it is not known whether this sitting training protocol is feasible and effective early after stroke. The research questions for this study were: in individuals within three months of a stroke who are able to sit unsupported

1. Does completion of a 2-week sitting training protocol improve sitting ability (maximum reach distance) and sitting quality (reaching performance)?
2. Does completion of a 2-week sitting training protocol have carry over benefits to standing up and walking?
3. Are any gains maintained six months after the cessation of training?

Method

Design: The effect of a sitting training protocol was tested using a prospective randomised design with pre-, post-, and follow-up tests (six months later). The second author checked patient files against the inclusion criteria. Eligible participants completed an initial assessment by the third author and were then randomised into an experimental

Table 1. Characteristics of participants.

Characteristic	All participants		Loss to follow-up	
	Exp (n = 6)	Con (n = 6)	Exp (n = 1)	Con (n = 2)
Age (yr), mean (SD)	60 (7)	74 (12)	58	69 (24)
Gender M:F	5:1	4:2	0:1	2:0
Side of hemiplegia R:L	3:3	1:5	1:0	0:2
Time from stroke to admission to trial (days), mean (SD) (range)	21 (8) (17 to 37)	37 (23) (13 to 75)	18	18 (6) (13 to 22)

Exp = experimental, Con = control

or control group. Randomisation was concealed from the recruiter and assessor by using sealed opaque envelopes containing the allocation, which was generated earlier by a person independent of the study using random number tables, blocked to ensure equal numbers of experimental and control participants. The third author remained blinded to group allocation and collected the outcomes measures post training and six months later. The collection of some outcome measures required two persons, one of whom was not blinded. To reduce bias, the blinded assessor (third author) gave all instructions and measured outcomes which were not collected by the computer. The design is outlined in Figure 1. The study was approved by the South Eastern Area Health Service and The University of Sydney Ethics Committees. All participants gave informed consent prior to participation.

Participants: Participants were recruited from Prince Henry Hospital, a rehabilitation facility in Sydney. Patients were included if they had: (1) a diagnosis of first stroke resulting in hemiplegia within the previous three months; (2) no orthopaedic problems which would interfere with the ability to perform seated reaching tasks; (3) no visual problems which would interfere with reaching to pick up objects or reading; (4) a score of at least 3 on Item 3 (sitting balance) of the Motor Assessment Scale for Stroke (Carr et al 1985); (5) the ability to reach with intact arm a distance equivalent to 140% of arm's length; (6) no major cognitive or perceptual problems identified using the short portable mental status questionnaire (Pfeiffer 1975); (7) no left neglect identified using the Letter Cancellation Test (Wilson et al 1987); (8) the ability to give informed consent; and (9) the ability to understand instructions.

Intervention: During the training period participants in both groups received all regular physiotherapy intervention other than training to improve sitting. All participants continued to attend other multidisciplinary rehabilitation services.

Participants in the experimental group were given the sitting training protocol designed by Dean and Shepherd (1997). The details and rationale for using this protocol has been reported fully elsewhere (Ada et al 2006). The protocol was based on earlier biomechanical studies of the characteristics of effective performance of seated reaching tasks by healthy individuals (Dean et al 1998, 1999a, 1999b). It was designed

to improve sitting by reaching beyond arm's length using the unaffected hand whilst focusing on: (1) smooth co-ordinated motion of the trunk and arm to get the hand to the object; (2) appropriate loading of the affected foot; and (3) preventing the use of maladaptive strategies such as widening the base of support. While reaching beyond arm's length, reach distance, direction, thigh support, seat height, and task were varied systematically. Training was progressed over the 2-week period by increasing the reach distance and the number of repetitions.

Participants in the control group completed a sham sitting training protocol designed to improve attention (Dean and Shepherd 1997). Sham training was performed so that participants would consider themselves involved in a training program, which would eliminate any effect due to placebo. This training involved participants completing a series of 11 cognitive-manipulative tasks. Participants were seated at a table, well supported in a chair with back and armrests, with their forearms resting on the table. The workspace was confined so that reach distance was less than 50% of arm's length which minimised perturbations to balance. Training was progressed over the 2-week period by increasing the number of repetitions and cognitive difficulty of the cognitive-manipulative tasks. Therefore, this training was sham sitting training because the perturbations to balance were minimal and were unlikely to lead to improvements in sitting.

Participants in both groups attempted all tasks in each session to ensure that the amount of practice was the same for all participants. Participants in each group received individual coaching aimed at improving performance. Both training programs consisted of 10 sessions spread over a 2-week period with each session lasting approximately 30 minutes.

Outcome measures: Sitting ability was the primary outcome measure. Sitting ability was measured as the maximum reach distance, using the intact arm, in three directions: forward, ipsilateral (45 degrees from the intact acromion away from the intact side), and across (45 degrees from the intact acromion across the body toward affected side). The procedure for measurement was similar to the Functional Reach Test in standing (Duncan et al 1990) and was the same as that used previously by Dean and Shepherd (1997).

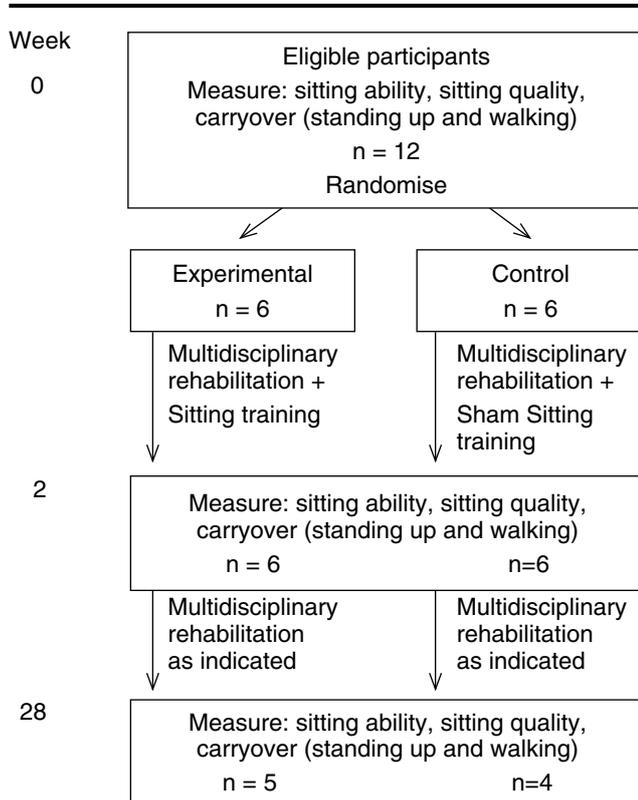


Figure 1. Design and flow of participants through the trial.

Participants had one practice trial followed by three actual trials in each direction. The best attempt for each direction was measured as the horizontal distance from the tip of the intact shoulder when the trunk was erect to the point reached on the table, and recorded to the nearest 0.01 m using a steel pole with 0.001 m increments. Previous research has indicated that the affected lower limb makes a significant contribution to support, balance, and propulsion during reaches in the forward and across directions, and very little contribution when reaching in the ipsilateral direction (Dean et al 1998, Dean et al 1999b). The primary outcome measure, sitting ability, therefore, was defined as the average maximum reach distance from the forward and across reaches.

A standardised 'reach to grasp and drink a glass of water' task was used to derive secondary outcome measures reflecting quality of sitting and was the same as that previously used by Dean and Shepherd (1997). Participants were instructed to use the intact arm to pick up a glass and drink from it. The reach distance was set at 140% of arm's length and this task was evaluated in the three directions. The water level was kept constant at 0.015 m from the top of the glass. The instructions given to each participant were 'Relax, ready, reach.' Participants had one practice trial followed by four trials in each direction. Pressure sensitive switches, portable force plates and laptop computer equipment were used to allow the collection of time and force data during the reach in the clinic. The secondary outcome measures that reflected sitting quality were the average reach movement time and the average peak vertical force through the affected foot during reaching expressed as a percentage of body weight obtained for reaches in the forward and across directions.

Carry over to mobility (standing up and walking) were also secondary outcomes. Standing up was measured as the peak vertical force through the affected foot during standing up (after thighs off) from a seat standardised to a height of 115% of lower leg length. The average peak vertical force, expressed as a percentage of body weight, of the four trials was calculated. Walking was measured as the speed in m/s during the 10 m Walk Test. The instructions given to each participant were 'Walk at a comfortable speed'. The time taken to walk over the middle 10 m of a 14 m walkway on a wooden floor in bare feet was measured with a stopwatch. The average of two trials was used to calculate walking speed.

Data analysis: Prior to commencing the study, a target of 20 participants was set. Given the results of the previous study where the SD for the primary outcome measure (maximum reach distance) was 0.1 m, this study was powered to find a between-group difference of 1.25 SD. This difference translates to 0.125 m which is the amount that the experimental group increased their reach distance compared with the control group in the previous study of chronic stroke (Dean and Shepherd 1997).

The immediate effects of training were analysed by comparing post-training scores between groups using analysis of covariance with the pretest score as a covariate. The retention effects were analysed by comparing the 6-month scores between groups using analysis of covariance with the pretest score as a covariate. Significance level was set at $p < 0.05$. Intention-to-treat analysis was used. (See Appendix 1 on the eAddenda for the complete details of the trial method).

Results

Flow of participants through the trial: Between January and June 2000, 12 eligible participants consented to participate. The first author continued to screen for potential participants, without success, until April 2001. This lack of success was attributable to the impending hospital closure and transfer of services. In April 2001 a decision was made to cease recruitment and complete the trial with the participants recruited prior to June 2000. Participant characteristics are outlined in Table 1. All 12 participants received intervention as allocated and completed post testing. Only 9 participants (5 Experimental and 4 Control) were available for six month follow up measures. Reasons for loss to follow-up were: 1 refusal (Experimental), 1 death (Control), and 1 no longer residing at address and unable to be contacted (Control). Flow of participants through the trial is outlined in Figure 1.

Compliance with trial method: Concealment of allocation from the recruiter and blinded assessor was successful. All training protocols were carried out as planned, with the exception that on two occasions participants were trained twice in one day because they were unavailable on a previous training day due to medical investigations.

Both groups participated in training protocols that were standardised in relation to amount of practice provided by the first and second author or undergraduate physiotherapy students under the supervision of the first author. The duration of the training sessions ranged from 20 to 55 minutes. Each participant in the experimental group completed 230 to 390 reaches (beyond arm's length) per session, and 3060 reaches over the 2-week period. As a

Table 2. Mean (SD) score, mean (SD) difference within groups, and mean (95% CI) difference between groups for all outcomes for the experimental group and the control group.

Score	Groups						Difference within groups				Difference between groups*	
	Week 0		Week 2		Week 28		Week 2 minus Week 0		Week 28 minus Week 0		Week 2 minus Week 0	Week 28 minus Week 0
	Exp (n = 6)	Con (n = 6)	Exp (n = 6)	Con (n = 6)	Exp (n = 5)	Con (n = 4)	Exp	Con	Exp	Con	Exp minus Con	Exp minus Con
Sitting ability												
Maximum reach distance (m)	1.12 (0.10)	1.10 (0.14)	1.25 (0.07)	1.07 (0.13)	1.26 (0.08)	1.07 (0.08)	0.13 (0.05)	-0.04 (0.03)	0.11 (0.08)	0.02 (0.08)	0.17 (0.12 to 0.21)	0.14 (0.01 to 0.26)
Sitting quality												
Reach movement time (s)	1.8 (0.3)	2.2 (0.8)	1.4 (0.3)	2.2 (0.7)	1.3 (0.2)	2.7 (1.2)	-0.4 (0.2)	0 (0.3)	-0.5 (0.2)	0.2 (0.7)	-0.5 (-0.8 to -0.2)	-0.6 (-1.6 to 0.3)
PVF through affected foot during reaching (% of BW)	20 (5)	20 (7)	34 (7)	20 (6)	30 (10)	22 (9)	13 (6)	0 (5)	10 (8)	3 (3)	13 (6 to 20)	8 (-4 to 19)
Carry over												
PVF through affected foot during standing up (% of BW)	42 (9)	51 (12)	61 (7)	45 (7)	59 (8)	45 (7)	19 (5)	-6 (7)	16 (9)	-7 (12)	21 (14 to 28)	17 (4 to 29)
Walking speed during 10 m Walk Test (m/s)	0.70 (0.35)	0.28 (0.33)	1.11 (0.49)	0.49 (0.32)	1.07 (0.39)	0.57 (0.38)	0.40 (0.35)	0.20 (0.16)	0.40 (0.38)	0.26 (0.39)	0.24 (-0.21 to 0.69)	0.31 (-0.36 to 1.0)

* = ANCOVA used for between group comparisons with baseline scores as covariate; Exp = experimental, Con = control, PVF = peak vertical force, BW = body weight

minimum, each participant in the control group completed 253 to 411 reaches (within arm's length) per session, and 3256 reaches over the 2-week period. That is, participants in the control group spent approximately the same amount of time in the sitting position and performed an equivalent number of reaches as those in the experimental group.

During the training period there was one adverse event. One participant from the experimental group slipped from the stool while training. The participant was lowered to the ground by the trainer. The participant was checked by medical staff and found to have sustained no injuries. The participant then completed the training session and continued with all other sessions.

Effect of intervention: Group data for the three measurement times as well as within- and between-group data are presented in Table 2, while individual data for the three measurement times are presented in Table 3 (for Table 3 see eAddenda).

With respect to sitting ability, both groups were similar at baseline with a maximum reach distance of approximately 1.1 m. After 2 weeks of training, as well as six months later, the experimental group had improved their maximum reach distance significantly compared with the control group.

For one of the quality of sitting measures, reach movement time, the experimental group reached faster than the control group at baseline. After two weeks' training, the experimental group had significantly reduced the time taken to reach by 0.5 s (95% CI 0.2 to 0.8) compared with the control group. However, there was no significant between-group difference after six months.

For the other quality of sitting measure, average peak vertical force through the affected foot during the forward and across reaches, both groups were similar at baseline. After two weeks' training, the experimental group had increased significantly the peak vertical force through the affected foot during reaching by 13% of body weight (95% CI 6 to 20) compared with the control group. There was no significant between-group difference after six months.

Carry over effects of the training were evaluated by examining standing up and walking. For standing up, after two weeks of training as well as six months later, the experimental group had increased its peak vertical force through the affected foot during standing up significantly compared with the control group. For walking, the experimental group walked faster than the control group at baseline with three of the control group unable to walk. Although both groups improved over time, there was no

significant between-group difference in walking speed during the 10 m Walk Test after two weeks of training or six months later.

Discussion

This randomised placebo-controlled clinical trial showed that a 2-week sitting training protocol improved sitting ability, sitting quality, and standing up in a group of participants who were within three months of their first stroke and able to sit unsupported. Furthermore, the gains in sitting ability and standing up were maintained six months after the cessation of training. This study also demonstrated that it is feasible to conduct this training early after stroke and our findings suggest that the protocol should be implemented early after stroke.

After two weeks' training, the experimental group significantly improved sitting ability, as measured by the average maximum reach distance during forward and across reaches, compared with the control group. The maximum reach distance achieved by the experimental participants early after stroke are on average 0.05 m better than the distance achieved by the experimental participants chronically after stroke (Dean and Shepherd 1997).

The secondary outcome measures which addressed sitting quality provide some insight into how the experimental group improved their sitting ability. After two weeks' training, during the standardised 'reach to grasp and drink from a glass' task in the forward and across directions, the experimental group reduced their movement time and increased the load through the affected foot significantly compared with the control group. The reach movement time achieved by the early experimental group was on average 0.4 s faster than that achieved by the chronic experimental group while the loading through the affected foot was 4% of body weight more (Dean and Shepherd 1997). Furthermore, the reach movement time achieved was on average 0.2 s faster than that reported for healthy people over 60 years while the loading through the affected foot was similar (Dean et al 1999b).

The carry over of the task-related training program to mobility was assessed by examining the performance of standing up and walking. Similar to the previous study (Dean and Shepherd 1997), there was a carry over to standing up but not to walking. For walking, the within-group data indicate that both groups improved their walking speed whereas for standing up, the within-group data indicate that only the experimental group increased their peak vertical force through the affected foot while the control group actually decreased their peak. The peak vertical force through the affected foot for standing up achieved by this experimental group was 8% of body weight more than that achieved by the chronic experimental group (Dean and Shepherd 1997) and is similar to values reported for healthy people (Cheng et al 1998, Hirschfeld et al 1999). At one level, the carry over to standing up is not surprising given the biomechanical similarities between reaching in sitting and the pre-extension phase of standing up. During sitting training, subjects practised moving their trunk forward rapidly over their centre of mass whilst loading their legs. Although these components were practised with the intention of improving sitting ability, they are also critical biomechanical components of the early phase of sit-to-stand (Shepherd and Gentile 1994). On the other hand, the between group differences in standing up is somewhat surprising given

that all participants were receiving standing up training as part of their multidisciplinary rehabilitation program. The fact that for the control group, force production through the affected lower limb decreased over the 2-week training period suggests that current rehabilitation for standing up is ineffective in teaching individuals after stroke to generate force through their affected foot. Our results indicate that repetitive reaching beyond arm's length in sitting would be more effective.

One of the limitations of this study was the small sample size. *A priori*, we set a target of 20 participants but after 1.5 years recruitment we were unable to meet this target before the hospital closed. In addition to the small sample size, there were three dropouts at the six month measurement which reduced the statistical power to determine whether the gains achieved were maintained. The six month data indicate that gains in sitting ability and standing up were maintained. However, the six month sitting quality of experimental participants was similar to that after training, indicating that our non-significant results were likely due to insufficient power to detect a smaller between-group difference rather than to a decline in gains attained.

Another limitation is that the inclusion criterion limits the external validity of this study. To participate in the study, individuals after stroke had to be able to sit unsupported and be able to reach 140% of arm's length. This criterion was necessary for participants to be able to complete the training and assessment tasks. Individuals unable to sit were, therefore, excluded from the study. Further research is required to discover effective interventions for those who cannot sit unsupported.

This study investigated the efficacy of a task-related training protocol designed to improve sitting ability and sitting quality and also to assess carry over to mobility in individuals who were less than three months post stroke. The results demonstrate that the protocol was both feasible and effective. We recommend that the protocol be implemented routinely early after stroke and suggest some modifications to avoid the one adverse event we encountered during training. In this event, one experimental subject slipped off the stool onto the floor. Similar adverse events could be avoided by using a wider stool and/or weighting the stool to avoid tipping.

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eAddenda: Appendix 1 and Table 3 available at www.physiotherapy.asn.au/AJP

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Statement regarding registration of clinical trials from the Editorial Board of *Australian Journal of Physiotherapy*

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