

# **Additional task-related practice improves mobility and upper limb function early after stroke: A randomised controlled trial**

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The purpose of this study was to investigate whether additional practice of either upper limb or mobility tasks improved functional outcome during inpatient stroke rehabilitation. This prospective, randomised, single blind clinical trial recruited 30 stroke subjects into either an Upper Limb or a Mobility Group. All subjects received their usual rehabilitation and an additional session of task-related practice using a circuit class format. Independent assessors, blinded to group allocation, tested all subjects. Outcome measures used were three items of the Jebsen Taylor Hand Function Test (JTHFT), two arm items of the Motor Assessment Scale (MAS), and three mobility measures, the Timed Up and Go Test (TUGT), Step Test, and Six Minute Walk Test (6MWT). Both groups improved significantly between pre- and post-tests on all of the mobility measures, however only the Upper Limb Group made a significant improvement on the JTHFT and MAS upper arm items. Following four weeks training, the Mobility Group had better locomotor ability than the Upper Limb Group (between-group differences in the 6MWT of 116.4 m, 95% CI 31.4 to 201.3 m, Step Test 2.6 repetitions, 95% CI -1.0 to 6.2 repetitions, and TUGT -7.6 sec, 95% CI -15.5 to 0.2 sec). The JTHFT dexterity scores in the Upper Limb Group were 6.5 sec (95% CI -7.4 to 20.4 sec) faster than the Mobility Group. Our findings support the use of additional task-related practice during inpatient stroke rehabilitation. The circuit class format was a practical and effective means to provide supervised additional practice that led to significant and meaningful functional gains. [Blennerhassett J and Dite W (2004): **Additional task-related practice improves mobility and upper limb function early after stroke: A randomised controlled trial. *Australian Journal of Physiotherapy* 50: 219–224]**

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## **Introduction**

Task-related practice is advocated during stroke rehabilitation to improve functional performance of daily activities such as walking and reaching to grasp objects (Carr and Shepherd 2002, Sonoda 1999). The amount of practice appears to be a crucial factor in effective treatment regimes (Duncan et al 2003, Kwakkel et al 1997) with emerging evidence that increased task-related practice improves walking ability in post-acute stroke (Hesse et al 1995, Kwakkel and Wagenaar 2002, Richards et al 1993) and use of the arm in chronic stroke (Taub et al 1999). Despite these findings, stroke patients have consistently been observed to spend long periods of time inactive during inpatient rehabilitation (Esmonde et al 1997, Mackey et al 1996). Limited practice of motor activities is likely to have a negative impact upon functional recovery and could prolong inpatient rehabilitation. However, patients are more likely to practise motor activities when supervised (Mackey et al 1996), highlighting the need for staffing resources to be allocated to programs that encourage more structured practice.

Several randomised controlled trials have demonstrated that structured exercise programs improve functional ability in chronic stroke survivors (Dean et al 2000, Duncan et al 1998, Potempa et al 1995, Teixeira-Salmela et al 1999). A pilot study by Dean et al (2000) employed a circuit class of task-related exercises over a four week period. The experimental group practised locomotor-related exercises and strengthening for the affected leg, while the control group performed exercises designed to improve upper limb function. Significant improvements that related to the type of

practice were observed only in the experimental group. While improved upper limb ability was noted in the control group, a detectable functional change was restricted to those individuals able to perform the hand dexterity test. However, a significant treatment effect for the control group was not found. Beneficial training effects for the subset of stroke survivors who have some voluntary control of the wrist and hand have also been noted in subacute (Duncan et al 2003) and chronic stroke (Taub et al 1999).

The circuit class offers a practical and efficient way to promote structured practice of task-related activities during stroke rehabilitation. Physiotherapy staff are able to supervise a group of patients as well as monitor and progress an individual patient's program. Recently, Salbach et al (2004) employed a similar intervention format to Dean et al (2000) on a larger sample of people who were within one year post-stroke and discharged from rehabilitation services. This study supported previous findings about the benefit of task-related practice on locomotor abilities in people with moderate walking deficits following a stroke. Another recent large randomised study demonstrated that structured and progressive exercise programs were effective in enhancing mobility and endurance in a similar stroke population (Duncan et al 2003). The program delivered by Duncan et al (2003) addressed multiple components and included endurance, strengthening, locomotor, and upper limb exercises. Other reports recommend that moderately intense aerobic exercise (Kelly et al 2003, Potempa et al 1995) and strengthening (Morris et al 2004) programs be incorporated into stroke rehabilitation to reduce physical impairments that contribute to disability.

Our aim was to employ a methodology similar to Dean et al (2000) and Salbach et al (2004) during inpatient stroke rehabilitation. The purpose of the study was to investigate whether additional task-related practice directed exclusively to either upper limb or mobility tasks improved functional outcome during inpatient stroke rehabilitation. A four-week intervention was selected to coincide with current length of inpatient rehabilitation. We hypothesised that (a) subjects from both groups would make significant functional improvement as a result of spontaneous recovery, interdisciplinary rehabilitation services, and participation in the additional training, and (b) subjects would make larger functional gains in the areas in which they received additional practice.

## Method

**Subjects** All inpatients with a primary diagnosis of stroke at Austin Health, Royal Talbot Rehabilitation Centre were monitored for eligibility for the study. The selection criteria were the ability to walk 10 metres with close supervision (with or without walking aids) and ability to provide informed consent. Patients were excluded if they had a deteriorating medical condition, or if they were independent community ambulators. For the purpose of this study, independent community ambulation was defined as a score of six on the Functional Ambulation Classification (Holden et al 1986) and the ability to walk further than 300 m in the Six Minute Walk Test (Enright and Sherrill 1998). Patients satisfying these criteria were identified by the treating physiotherapist. These patients were then invited by a researcher to participate in the study and gave voluntary consent prior to commencing the study. Ethics approval was obtained from Austin Health Human Research Ethics Committee. The study was conducted over an 18 month period between September 2001 and February 2003.

**Sample size** Based on a standard deviation of 4.2 steps/15 seconds (Hill et al 1996), a sample size of 15 subjects per group provides a 90% power to detect an effect on the step test of 5 steps/15 seconds, assuming a significance level of 0.05.

**Procedure** This was a prospective, randomised, single blind clinical trial. Subjects were assigned randomly to either an Upper Limb or Mobility training group. Randomisation was performed by a person independent from the study drawing a pre-sealed opaque envelope that specified group allocation.

In addition to the study intervention, all subjects received their usual interdisciplinary rehabilitation, which included one hour of physiotherapy, five days a week. This physiotherapy was based predominantly upon the Movement Science approach (Carr and Shepherd 2002). The duration of interdisciplinary therapy was recorded. The amount of physiotherapy time related to mobility and upper limb tasks was also documented. Subjects were not blinded to the research procedure although they were not told of the study hypotheses. Treating physiotherapists were not told of group allocations although they may have found out through interaction with subjects during physiotherapy treatments.

**Training groups** Both the Mobility and Upper Limb Groups received additional task-related practice for one hour a day, five days per week for four weeks. Each session consisted of a circuit of 10 five-minute workstations, with up to four subjects in each session. A physiotherapy department staff member supervised all sessions closely, and all activities were

**Table 1.** Subject details for each group. Values are counts or means (SD).

	Mobility (n = 15)	Upper Limb (n = 15)
Male	8	9
Female	7	6
Age (years)	53.9 (19.8)	56.3 (10.5)
Stroke type		
Infarct	11	11
Haemorrhage	4	4
Side affected		
Right	8	6
Left	7	9

customised and progressed to suit individual subjects. Mobility circuit classes were conducted separately from the Upper Limb sessions.

Mobility Group activities included warm-up and endurance tasks using stationary bikes and treadmills, followed by functional tasks such as sit to stand, step-ups, obstacle course walking, standing balance, stretching as required, and strengthening using traditional gymnasium equipment. Upper Limb Group activities commenced with a warm-up (arm ergometer) followed by functional tasks to improve reach and grasp, hand-eye coordination activities, stretching as required, and strengthening using traditional gymnasium equipment. Therapist-assisted exercises were incorporated for subjects with limited control of arm or hand movement.

After the four weeks training, participants ceased the additional practice and continued with their interdisciplinary rehabilitation program. The overall rehabilitation goals were made independently to the conduct of the study.

**Dependent variables** Measures of both mobility and upper limb function were performed on three occasions: 1) prior to commencement in the trial, 2) immediately after the 4-week additional training, and 3) at follow-up six months after completing the additional training. An independent assessor who was blinded to group allocation and previous test results, and was not involved in the treatment of the subject, performed all tests. The order of tests was consistent for all subjects. Testing procedures were standardised in accordance to previous reports. The tests of locomotor performance were the Six Minute Walk Test (6MWT) (Enright and Sherrill 1998), the Timed Up and Go Test (TUGT) (Podsiadlo and Richardson 1991) and the Step Test (Hill et al 1996). For the Step Test, the lower of the two measures recorded for each leg was selected as the score (Dite and Temple 2002, Hill 1997). Measurement of upper limb ability included the upper arm and hand items of the Motor Assessment Scale (MAS) (Carr et al 1985) and the combined time for three sub-tests from the Jebsen Taylor Hand Function Test (JTHFT) (Jebsen et al 1969): checkers, small objects, and large heavy objects.

**Data analysis** Independent sample t-tests and chi-square tests were used to examine between-group differences for baseline, treatment time and length of stay data. Two (group: mobility, upper limb) x three (time: initial, 4 weeks, 6 months) split-plot ANOVAs, followed by tests of simple main

**Table 2.** Rehabilitation time frames and training session details for each group. Values are means (SD).

	Mobility (n = 15)	Upper Limb (n = 15)
Stroke onset to start group (days)	36.0 (25.1)	50.1 (49.2)
Admission to start group (days)	18.3 (14.1)	23.7 (31.8)
Start group to discharge (days)	40.7 (28.1)	67.5 (43.1)
Length of inpatient rehabilitation (days)	58.3 (30.1)	91.3 (53.6)
Number of additional practice sessions	16.4 (1.9)	15.9 (2.4)
Total interdisciplinary therapy time during 4 weeks (minutes)	1871 (529)	1906 (594)

**Table 3.** Outcomes for both groups. Means (SD) are reported for all variables except medians (IQR) for the MAS. n = 15 in both groups except for the JTHFT where n = 11 at initial, 12 at four weeks, and 11 at six months. One participant from the Upper Limb Group was not re-tested at six months.

Test	Group	Initial	4 weeks	6 months
6MWT (m)	Mobility	183 (85)	404 (101)	416 (171)
	Upper Limb	181 (85)	288 (124)	313 (154)
TUGT (sec)	Mobility	24.3 (7.0)	11.5 (3.8)	10.8 (4.5)
	Upper Limb	25.3 (17)	19.1 (14.4)	21.3 (30.3)
Step Test (number/15 sec)	Mobility	5.1 (3.3)	11.1 (5.0)	12.1 (5.7)
	Upper Limb	5.2 (3.8)	8.5 (4.6)	9.5 (5.3)
JTHFT (sec)	Mobility	39.6 (32.7)	30.8 (19.9)	31.0 (33.2)
	Upper Limb	41.8 (19.4)	24.3 (11.3)	23.6 (12.2)
MAS Upper Arm	Mobility	5 (1–6)	6 (4–6)	6 (5–6)
	Upper Limb	5 (2–5)	6 (5–6)	5 (4.5–6)
MAS Hand	Mobility	6 (2–6)	6 (5–6)	6 (3–6)
	Upper Limb	6 (0–5)	6 (5–6)	6 (4.2–6)

6MWT = Six Minute Walk Test, TUGT = Timed Up and Go Test, JTHFT = Jebsen Taylor Hand Function Test, MAS = Motor Assessment Scale, m = metres, sec = seconds

effects were conducted on the 6MWT, Step Test, TUGT, and JTHFT scores. Log transformations were performed on the TUGT and JTHFT where the assumption of normality was violated (Kolmogorov-Smirnov-Lilliefors  $p < 0.05$ ). The treatment effect sizes (differences between the two groups) at the four week test were evaluated using the effect size  $d$ . The MAS scores were analysed using the Mann-Whitney U test for between-group differences and Wilcoxon signed-ranks test for repeated measures. Alpha was set at 0.05. The Bonferroni correction was used to control the family-wise Type I error rate, with differences considered significant if  $p < 0.008$  (0.05/6). All data were analysed by intention to treat.

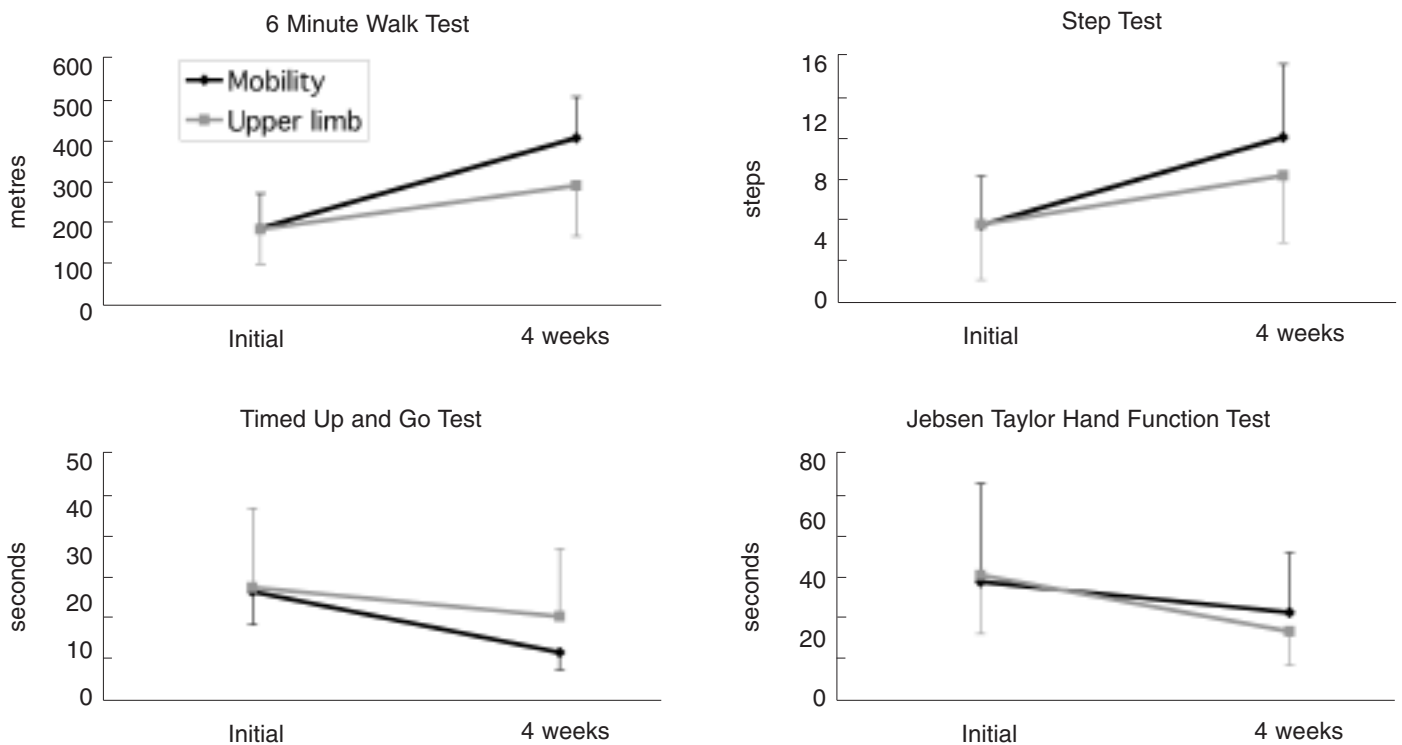
## Results

Thirty subjects were recruited into the study and their demographic details are provided in Table 1. Twenty-nine of the subjects recruited were admitted to rehabilitation with their first stroke. One subject from the Mobility Group had had a previous stroke, but had made a good recovery and was living independently in the community. Fifteen subjects were allocated to each training group. All subjects completed four weeks of additional training and follow-up was 100% at four weeks and 97% at six months. All subjects completed the mobility and MAS measurements on the initial and four week test. There were data missing from the JTHFT. At the four week assessment only 12 subjects from each group were able

to perform the JTHFT. Of these subjects, the Mobility Group had six left and six right side affected, and the Upper Limb Group had seven left and five right side affected. One subject from the Upper Limb Group was not tested at the six month follow-up as he sustained a hip fracture secondary to a fall after discharge.

The groups were comparable at commencement of the study for factors such as age, gender, type of stroke, side affected, time from stroke onset to rehabilitation admission, or time between onset and commencing the study ( $p = 0.52$  to 1.00) (see Tables 1 and 2). The number of additional practice sessions attended and total duration of interdisciplinary therapy were similar for the two groups ( $p = 0.57$  to 0.87). In addition, no difference was found between groups for the duration of mobility and upper limb related practice delivered within the usual physiotherapy sessions ( $p = 0.35$  to 0.60). Interestingly, there was a trend towards the Mobility Group having a shorter rehabilitation stay with regard to days between commencing the study and discharge ( $p = 0.05$ ) and total length of rehabilitation ( $p = 0.05$ ) (see Table 2).

A significant group by time interaction was found for the 6MWT ( $p = 0.001$ ), and the interaction approached significance for the TUGT ( $p = 0.009$ ) (see Figure 1). When examining between-group differences across the three time levels, analysis of simple main effects found no significant



**Figure 1.** Time by group interaction for continuous variables (means and standard deviations) across the four week intervention.

differences. However, there was a trend at the four week post-test for the Mobility Group to walk further in the 6MWT ( $p = 0.01$ ) and faster in the TUGT ( $p = 0.02$ ).

Analysis of simple main effects for within-group changes over time revealed significant improvements for the Mobility Group on the 6MWT, Step Test, and TUGT (all  $p < 0.001$ ). The Upper Limb Group also made significant improvements on the 6MWT ( $p < 0.001$ ), Step Test ( $p = 0.001$ ), TUGT ( $p = 0.006$ ), and JTHFT ( $p = 0.005$ ). Further analysis of time differences identified that all significant changes occurred between the initial to four week test and the initial to six month test. No significant changes for either group occurred between the four week to six month tests ( $p = 0.19$  to  $0.59$ ). Only the Upper Limb Group made significant improvements over time on the MAS upper arm item, again with changes between the initial and four week tests ( $p < 0.001$ ) and initial and six month tests ( $p = 0.004$ ). No other significant changes for the MAS scores were found (see Table 3).

At the four week post training test, a large between-group intervention treatment effect was found for the 6MWT ( $d = 1.00$ , 95% CI 0.24 to 1.76). Treatment effect sizes were moderate for the TUGT ( $d = 0.71$ , 95% CI -0.03 to 1.44), Step Test ( $d = 0.53$ , 95% CI -0.20 to 1.26) and JTHFT ( $d = 0.36$ , 95% CI -0.42 to 1.19). In clinical terms, the mean difference between the two groups following the four weeks training was 116 m (95% CI 31 to 201 m) for the 6MWT, 2.6 repetitions (95% CI -1.0 to 6.2 repetitions) for the Step Test, -7.6 sec (95% CI -15.5 to 0.2 sec) for the TUGT, and 6.5 sec (95% CI -7.4 to 20.4 sec) for the JTHFT. The direction of change demonstrated greater locomotor ability for the Mobility Group and greater dexterity for the Upper Limb Group.

## Discussion

As hypothesised, subjects from both groups made functional gains over the intervention period. Larger gains were observed in both groups that were specific to the type of additional practice received. These gains exceeded that of usual rehabilitation combined with spontaneous recovery, providing support for the use of task-related training during stroke rehabilitation. The one-hour sessions of additional training were well tolerated by all subjects and were realistic to provide within the constraints of our physiotherapy department.

Task-related training effects were found with the mobility and upper limb variables. The largest between-group treatment effect across the four week intervention was found for the 6MWT. This supports previous studies that also identified the greatest impact of mobility training to be on 6MWT (Salbach et al 2004). The much larger 6MWT improvements and between-group differences in the present study, compared with Salbach et al 2004, are likely to be due to our sample being earlier post-stroke (including more spontaneous recovery), having a lower initial 6MWT, and being substantially younger. In the present study, smaller identifiable task-related training effects were found for the TUGT, Step Test, and JTHFT. Only the Upper Limb Group made significant improvements in the upper arm item of the MAS and the JTHFT, despite the loss of statistical power as one-third of each group was unable to perform the hand dexterity test. Other factors that may influence recovery after stroke, such as functional ability, gender, age, type and side of stroke, time since stroke onset, and amount of usual rehabilitation were comparable between groups. Therefore,

the specific training effects demonstrated in our study are likely to reflect the efficacy of the additional practice received. The interpretation of these results needs to consider the limitation that this was a clinical trial using a sample of convenience.

Our findings provide evidence that additional task-related practice is effective in improving functional outcomes during inpatient stroke rehabilitation. Moreover, the extra practice appears to lead to clinically meaningful changes in functional ability. For example, the Mobility Group walked on average 116 metres further in the 6MWT than the Upper Limb Group. Enhanced endurance may have important implications for the level of walking disability, with previous findings of limited walking endurance in sub-acute (Kelly et al 2003) and chronic stroke (Dean et al 2001, Macko et al 1997). The larger gains in standing balance measured in the Mobility Group may also reduce risks of falls as noted in the elderly (Dite and Temple 2002, Shumway-Cook et al 2000). Similarly, the enhanced upper limb performance achieved by extra practice has potential benefits for arm use in daily life, but it is unknown whether these changes were clinically relevant. For instance, the Upper Limb Group could perform the three timed hand dexterity tests 6.5 seconds faster than the Mobility Group. However, only one person from each group who was initially unable to perform the JTHFT regained sufficient hand movement to perform the test. Previous research has also reported that improved upper limb ability was confined to a subset of sub-acute stroke survivors (Duncan et al 2003), and reflects the heterogeneous nature of arm recovery after stroke (Basmajian and Gowland 1987). Further studies into the efficacy of specific training regimes appropriate for differing levels of upper limb capabilities are required.

The trend towards a shorter length of rehabilitation stay for the Mobility Group subjects has potential implications for rehabilitation costs. Caution is necessary when interpreting this finding because length of rehabilitation was considered a secondary outcome, and would have been influenced by extraneous variables. Further study into the effect of additional practice on length of stay is warranted.

No additional changes were noted between the completion of the study intervention and the 6-month follow-up. Within this phase, no control was applied to the rehabilitation services delivered. At six months, there was no difference between the two groups. At the follow-up, the outcome of several individuals from either group is noteworthy. The individual who could not be tested at six months due to a fractured hip following a fall was classified as a high falls risk by the scores of the TUGT and Step Test (Dite and Temple 2002, Shumway-Cook et al 2000) at four weeks. Two subjects deteriorated in all mobility measures and five decreased their 6MWT distance by more than 15 per cent. Others (Dean et al 2000, Lindmark and Hamrin 1995, Potempa et al 1995) have raised concerns that physical ability can deteriorate after discharge from rehabilitation. These observations support recommendations by Dean et al (2001) that clinical measurements such as the 6MWT be used to monitor stroke patients after discharge from rehabilitation, and that exercise programs aiming to prevent the deleterious effects of inactivity be encouraged.

Our findings support the use of additional task-related practice during inpatient rehabilitation. The circuit class format was a practical and effective means of providing

supervised additional practice that lead to measurable functional gains. These findings may be generalised to other sub-acute stroke patients with due considerations given to the limitations of our clinical sample. In particular, our subjects could walk short distances with close supervision and were relatively young, with only four subjects from each group being over 65 years of age.

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## References

- Basmajian JV and Gowland CA (1987): The many hidden faces of stroke: A call for action. *Archives of Physical Medicine and Rehabilitation* 68: 319.
- Carr JH, Shepherd RB, Nordholm L and Lynne D (1985): Investigation of a new Motor Assessment Scale for stroke patients. *Physical Therapy* 65: 175–180.
- Carr JH and Shepherd RB (2002): *Stroke Rehabilitation: Guidelines for Exercise and Training to Optimize Motor Skill*. Oxford: Butterworth-Heinemann.
- Dean CM, Richards CL and Malouin F (2001): Walking speed over 10 metres overestimates locomotor capacity after stroke. *Clinical Rehabilitation* 15: 415–421.
- Dean CM, Richards CL and Malouin F (2000): Task-related circuit training improves performance of locomotor tasks in chronic stroke: A randomized controlled pilot study. *Archives of Physical Medicine and Rehabilitation* 81: 409–417.
- Dite W and Temple VA (2002): A clinical test of stepping and change of direction to identify multiple falling older adults. *Archives of Physical Medicine and Rehabilitation* 83: 1566–1571.
- Duncan P, Richards L, Wallace D, Stoker-Yates J, Pohl P, Luchies C, Ogle A and Studenski S (1998): A randomized, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. *Stroke* 29: 2055–2060.
- Duncan P, Studenski S, Richards L, Gollub S, Lai SM, Reker D, Perera S, Yates J, Koch V, Rigler S and Johnson D (2003): Randomized clinical trial of therapeutic exercise in subacute stroke. *Stroke* 34: 2173–2180.
- Enright PL and Sherrill DL (1998): Reference equations for the six-minute walk test in healthy adults. *American Journal of Respiratory and Critical Care Medicine* 158: 1384–1387.
- Esmonde T, McGinley J, Wittwer J, Goldie P and Martin C (1997): Stroke rehabilitation: patient activity during non-therapy time. *Australian Journal of Physiotherapy* 43: 43–51.
- Hesse S, Bertelt C, Jahnke MT, Schaffrin F, Baake P, Malezic M and Mauritz KH (1995): Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. *Stroke* 26: 976–981.
- Hill K, Bernhardt J, McGann A, Maltese D and Berkovits D (1996): A new test of dynamic standing balance for stroke patients: Reliability, validity and comparison with healthy elderly. *Physiotherapy Canada* 48: 257–262.
- Hill KD (1997): *Studies of Balance in Older People*. Unpublished PhD Thesis, The University of Melbourne, Melbourne.

- Holden M, Gill K and Magliozzi M (1986): Gait assessment for neurologically impaired patients. Standards for outcome assessment. *Physical Therapy* 66: 1530–1539.
- Jebsen RH, Taylor N, Trieschmann RB, Trotter MJ and Howard LA (1969): An objective and standardised test of hand function. *Archives of Physical Medicine and Rehabilitation* 50: 311–319.
- Kelly JO, Kilbreath SL, Davis GM, Zeman B and Raymond J (2003): Cardiorespiratory fitness and walking ability in subacute stroke patients. *Archives of Physical Medicine and Rehabilitation* 84: 1780–1785.
- Kwakkel G and Wagenaar RC (2002): Effect of duration of upper- and lower-extremity rehabilitation sessions and walking speed on recovery of interlimb coordination in hemiplegic gait. *Physical Therapy* 82: 432–448.
- Kwakkel G, Wagenaar RC, Koelman TW, Lankhorst GJ and Koestier JC (1997): Effects of intensity of rehabilitation after stroke. A research synthesis. *Stroke* 28: 1550–1556.
- Lindmark B and Hamrin E (1995): A five-year follow-up of stroke survivors: Motor function and activities of daily living. *Clinical Rehabilitation* 9: 1–9.
- Mackey F, Ada L, Heard R and Adams R (1996): Stroke rehabilitation: Are highly structured units more conducive to physical activity than less structured units? *Archives of Physical Medicine and Rehabilitation* 77: 1066–1070.
- Macko RF, DeSouza CA, Tretter LD, Silver KH, Smith GV, Anderson PA, Tomoyasu N, Gorman P and Dengel DR (1997): Treadmill aerobic exercise training reduces the energy expenditure and cardiovascular demands of hemiparetic gait in chronic stroke patients. *Stroke* 28: 326–330.
- Morris SL, Dodd KJ and Morris ME (2004): Outcomes of progressive resistance strength training following stroke: A systematic review. *Clinical Rehabilitation* 18: 27–39.
- Podsiadlo D and Richardson S (1991): The timed “up and go” test: A test of basic functional mobility for frail elderly persons. *Journal of American Geriatric Society* 39: 142–148.
- Potempa K, Lopez M, Braun LT, Szidon P, Fogg L and Tincknell T (1995): Physiological outcomes of aerobic exercise training in hemiparetic stroke patients. *Stroke* 26: 101–105.
- Richards CL, Malouin F, Wood-Dauphinee S, Williams JI, Bouchard JP and Brunet D (1993): Task-specific physical therapy for optimization of gait recovery in acute stroke patients. *Archives of Physical Medicine and Rehabilitation* 74: 612–620.
- Salbach NM, Mayo NE, Wood-Dauphinee S, Hanley JA, Richards CL, Cote R (2004): A task-orientated intervention enhances walking distance and speed in the first year post stroke: A randomized controlled trial. *Clinical Rehabilitation* 18: 509–519.
- Shumway-Cook A, Brauer S and Woollacott M (2000): Predicting the probability for falls in community-dwelling older adults using the timed up and go test. *Physical Therapy* 80: 896–903.
- Sonoda S (1999): Recovery from stroke. *Critical Reviews in Physical and Rehabilitation Medicine* 11: 75–109.
- Taub E, Uswatte G and Pidikiti R (1999): Constraint-induced movement therapy: A new family of techniques with broad application to physical rehabilitation. A clinical review. *Journal of Rehabilitation Research and Development* 36: 237–251.
- Teixeira-Salmela LF, Olney SJ, Nadeau S and Brouwer B (1999): Muscle strengthening and physical conditioning to reduce impairment and disability in chronic stroke survivors. *Archives of Physical Medicine and Rehabilitation* 80: 1211–1218.