Usual walking performance following rehab

Circuit-based rehabilitation improves gait endurance but not usual walking activity in chronic stroke: a randomised clinical trial.

Abstract

Objective: To determine if circuit-based rehabilitation would increase the amount and rate of walking that an individual with stroke carries out in their usual environment.

Design: Single blind randomised controlled trial

Setting: Rehabilitation clinic

Participants: Sixty participants with a residual gait deficit at least six months following stroke originally enrolled in the study. Two withdrew in the initial phase leaving 58 participants (median age 71.5 years (range 39.0-89.0)) who were randomised to the two intervention groups.

Interventions: The exercise group had 12 sessions of clinic-based rehabilitation delivered in a circuit class designed to improve walking. The control group received a comparable duration of group social and educational classes.

Main Outcome Measures: Usual walking performance was assessed using the StepWatch Activity Monitor. Clinical tests were gait speed (timed 10 metre walk) and endurance (Six minute walk test), confidence (Activities-Based Confidence Scale), self reported mobility (Rivermead Mobility Index) and self-reported physical activity (Physical Activity and Disability Scale).

Results: Intention-to-treat analysis revealed that the exercise group showed a significantly greater distance for the 6MWT compared to the control group immediately following the intervention (p=0.030) but that this effect was not retained three months later. There were no changes in the StepWatch measures of usual walking performance for either group. The exercise and

control groups had significantly different gait speed (p=0.038) and scores on the RMI (p=0.025) at the three-month follow-up. These differences represented a greater decline in the control group compared to the exercise group for both outcome measures..

Conclusions: Circuit-based rehabilitation leads to improvements in gait endurance but does not change the amount or rate of walking performance in usual environments. Clinical gains made by the exercise group were lost three months later. Future studies should consider whether rehabilitation needs to occur in usual environments in order to improve walking performance.

Key words: Rehabilitation; stroke; walking;

Introduction

Persistent physical disability is reported by 50-65% of individuals with stroke making it the leading cause of long term disability in adults.[1-3] Although most recovery occurs in the first six months following stroke,[4] there is mounting evidence that rehabilitation beyond this time may result in further gains.[5, 6]

Walking remains a major focus of physical therapy programmes,[7] although the specific components of training that optimise walking recovery are less certain. Task oriented gait training, including walking in all directions, over different surfaces, obstacles, inclines and steps, consistently results in improved clinical measures of gait, particularly self selected gait speed and endurance.[8-14]

Strength training has been included in some physical therapy programmes with more variable results.[15] There is relatively consistent evidence for gains in strength when progressive resistance principles are applied.[16-18] However, the translation of benefits from strength training to functional activities, such as walking, is less clear.[18] The variable results seen in different studies may reflect differences in strength training protocols,[19] as some studies do not demonstrate evidence of adequate overload of the muscle.[20, 21]

Although rehabilitation leads to measurable gains in walking speed and endurance, and amelioration of impairments, it is not known whether these improvements translate into an improvement in function once an individual returns to their own environment.[22] The aim of this study was to determine if

rehabilitation, delivered as a circuit exercise programme, would increase the amount and rate of walking that an individual with stroke carries out in their usual environment.

Methods

This is a prospective, randomised, single-blind, attention-controlled clinical trial of circuit-based rehabilitation in adults at least six months after stroke. Participants were a convenience sample recruited through the Stroke Foundation of New Zealand, stroke clubs and the local hospital stroke service. Information sheets about the study were provided to potential candidates who were invited to contact the principal investigator if they wished to participate. The study was approved by the Regional Ethics Committee and each participant provided informed consent. Procedures were conducted in accordance with the Declaration of Helsinki.

Participants were eligible for inclusion if they had had one or more strokes more than six months earlier, had been discharged from rehabilitation and were able to walk independently (with an aid if necessary). Some residual gait difficulty was required, as defined by a score of less than 2 on at least one of the walking items of the physical functioning scale of the 36 Item Short Form Health Survey.[23] Participants were excluded if they had progressive neurological disease, other significant health problems that adversely affected walking ability, more than two falls in the previous six months, unstable cardiac conditions, uncontrolled hypertension or congestive heart failure. A letter

detailing the proposed programme and inclusion and exclusion criteria was sent to each participant's general practitioner for medical clearance prior to enrolment in the study.

Participants were randomly assigned to the exercise or control group through the use of computer generated random numbers by an individual not associated with the study. Randomisation was revealed to each participant by the principal investigator following their second baseline assessment.

Participants allocated to the exercise group participated in 12 group circuit exercise sessions three times a week for four weeks. The groups contained up to nine participants and were led by one of the investigators (SM) assisted by two physiotherapy students. There were 15 stations in the circuit, which were graded to each participant's ability and progressed as tolerated. Each station contained either a task-oriented gait or standing balance activity or strengthening of a lower extremity muscle in a way designed to improve gait. Details of the content of each station and examples of progressions are provided in Appendix 1. The total exercise time was 30 minutes, although sessions lasted between 50-60 minutes, including stretching. Participants spent two minutes at each station of the circuit, with time between stations to allow movement between stations and receive instructions for the next station. Details about exercise intensity and/or repetitions performed at each station were recorded for each participant.

Participants in the control group attended eight 90 minute sessions over four weeks in groups of up to eight. The control group was run by an occupational therapist and consisted of four social and four educational sessions. The content of the sessions is outlined in Appendix 2. The duration of the control group sessions was designed to match the length of the time of the intervention sessions in order to control for possible effects of dosage. Matching for duration and not number of sessions was a pragmatic choice based on resources, allowing one intervention session per weekday to be scheduled over the four week intervention period. Both the control and exercise group sessions took place in a private rehabilitation clinic.

Outcome Measures

The mean number of steps per day as measured by the StepWatch Activity Monitor[a] was used as the primary outcome measure. The monitor contains a custom sensor that uses a combination of acceleration, position and timing to determine the number and rate of steps taken. The output of the StepWatch is based on the number of steps taken on one leg, which is doubled to represent steps taken on both legs.[24-27] The StepWatch has been shown to have criterion validity[28, 29] and is reliable[25, 30] for step counting in individuals with stroke. Sensitivity has been demonstrated during the subacute phase of stroke.[24]

The monitor was initially calibrated and attached to the lateral side of the ankle of the non-paretic leg with a strap or cuff. The monitor has an infrared light that flashes with every step, which were matched to a manual count of steps during walking five metres at each of three walking speeds (fast, slow and self

142 selected). The sensitivity and cadence settings were adjusted, if necessary,
143 until the flashes corresponded exactly with the manual count during the three
144 walking speeds. Participants were then instructed to wear the monitor for three
145 consecutive days, removing it for sleeping and showering. Data were exported
146 to Excel[b] for initial analysis. On subsequent testing sessions, participants were
147 instructed to wear the StepWatch for the same three days of the week as worn
148 following the first testing session. The consecutive StepWatch data was
149 averaged over the three days.
150
151 The secondary outcome measures were walking speed and endurance,
152 confidence during mobility tasks and self reported activity. Participants used
153 their usual assistive device for these two tests, and they were tested at
154 subsequent sessions with the same assistive device. Self selected gait speed
155 was measured by a timed 10 metre walk test where a person walks at
156 comfortable pace over 10 metres. Gait endurance was tested by the six minute
157 walk test (6MWT),[31] although it should be acknowledged that the 6MWT is also
158 influenced by other stroke-related impairments like balance and strength.[32] Both
159 the timed 10 metre walk and 6MWT are used commonly [33] and have good
160 psychometric properties.[34]
161
162 The Activities-specific Balance and Confidence scale (ABC) was used to reflect
163 confidence during 15 activities of daily living. In the stroke population, the ABC
164 has been shown to have high test-retest reliability [35, 36] and high internal
165 consistency.[36] Moderate correlation has been shown with the Berg Balance
166 Scale, supporting criterion-related validity.[35]

The Rivermead Mobility Index (RMI) was used to capture self reported mobility. The RMI is a self report of ability to perform up to 15 mobility items (six specifically related to walking), with answers given of either “yes” or “no”. The RMI reflects a breadth of walking conditions, such as walking over uneven surfaces and walking outside that are not evaluated by the commonly used timed walking tests.[33] The highest score of 15 indicates an ability to climb up and down four steps with no rail and run 10 metres.

The Physical Activity and Disability Scale (PADS) was used to determine the level of activity performed by an individual. The PADS is specifically designed to reflect activities potentially performed by individuals with disabilities.[37] Satisfactory reliability (ICC = 0.85) and validity are reported by the developers of the scale.[38]

Following the post-intervention testing session, each participant was asked whether they thought there had been any change in their walking over the intervention period and/or while they were wearing the StepWatch, and, if so, whether they thought the change related to quality, speed or quantity of walking.

Outcome assessment was performed by an independent physiotherapist blinded to treatment assignment. Participants were not blinded, as they were aware of their own group allocation, which was revealed after the second testing session. Participants were instructed not to discuss group allocation with

the assessor. The testing sessions were carried out in the same rehabilitation clinic as the intervention groups, but were scheduled at different times to maintain blinding of the assessor.

Two baseline testing sessions 3 weeks apart were performed to ensure that participant measures were stable. The testing sessions were repeated immediately following the group sessions (post-intervention) and at three months (follow-up). All tests were performed once and all testing sessions were identical.

Statistical Analysis

Baseline Data: Tests for normality were done for all continuous variables. Simple descriptive statistics were used to summarise demographic and baseline sample characteristics. The two baseline measures were tested for stability by using a coefficient of variation (standard deviation expressed as a percentage of the mean) and then averaged to yield baseline outcome measures. Baseline population characteristics were compared between intervention groups using Chi-Square or Fisher's Exact tests for categorical variables, and Wilcoxon-Mann-Whitney tests for continuous variables. Analysis of variance (ANOVA) for unbalanced designs was used to test for group differences in baseline measures.

Post-intervention measures: Intention to treat analysis was used for all outcomes with a carry forward method used to account for missing data.[39] For each parametric outcome at post-intervention and 3-months follow-up, analysis

of covariance (ANCOVA) was used to test for intervention group differences with the baseline measure as the covariate. Wilcoxon Signed Rank-Sum test was used to assess whether there were intervention group differences at post-intervention and 3-months follow-up, for non-parametric outcomes..

Calculations were performed using SAS[c] .

The power calculation was based on data from Michael et al,[26] who reported 2837 $\pm$ 1503 mean steps/day in 50 participants with stroke. A 40% increase in mean steps/day was chosen as the smallest relevant difference, as this level of change reflects the smallest amount not attributable to normal daily variation. [30] A sample size of 25 participants would therefore have greater than 90% power to detect a 40% within-group change in mean steps/day, assuming a correlation coefficient of at least r=0.4, and a significance level of 0.05. A sample size of 25 participants in each group has 80% power to detect a 42% between-group change in mean steps/day, with a significance level of 0.05

Results

Sixty participants (median 71.5 years old (range 39-89) and median 3.9 years following stroke (range 0.5-18.7 years) were enrolled in the study between June 2007 and February 2008. However, two participants withdrew before randomisation leaving 58 individuals who are the subject of this study (Figure 1). Thirty-one participants were randomised to the exercise group and 27 to the control group. The median score on the physical functioning index of the 36 Item Short Form Health Survey was 17 for the control group and 19 for the

exercise group (range 10-28). A maximum score of 30 on the physical functioning index indicates no limitations with all items, including walking more than a mile, climbing several flights of stairs and running, whereas a score of 10 indicates significant limitations with all items. All participants walked independently and 26 (45%) used an assistive device. There was no significant difference between the baseline characteristics of the two groups (Table 1).

Of the 55 participants who completed the interventions, adherence to both groups was high with participants attending an average of 11.1 ± 1.7 hours (7.4 ± 1.2 sessions) in the control group and 10.8 ± 1.6 hours in the exercise group, both out of a possible 12 hours. Unmasking of the independent assessor occurred in the case of three participants, who inadvertently stated or implied their group allocation.

Baseline

Coefficients of variation calculated from the two baseline measures ranged from 5.14% for the RMI to 21.30% for the PADS in the control group and 3.49% for the RMI to 34.67% for the PADS in the exercise group (Table 2). With the exception of the PADS for each group, the coefficients of variation were all under 15% and were under 10% for the 6MWT and gait speed.

There were differences between control and exercise group clinical tests at baseline. The exercise group had greater distance on the 6MWT (p=0.028), mean steps/day (p=0.021), peak activity index (p=0.008) and highest step rate in one minute (p=0.019) (Table 2). Imbalances seen were likely to be due to

chance as they were collected while randomisation was concealed from the assessor and the participant. These differences were used as covariates in subsequent analysis.

Post-intervention

Table 3 shows the observed outcome scores at baseline, post intervention and at three months follow-up and the adjusted means, with the baseline values as covariates, at post intervention and follow-up. Immediately following the intervention, the exercise group showed a significantly greater distance for the 6MWT compared to the control group (p=0.030) (Table 3). However, this did not translate into increased activity in the participants' usual environments with no changes in any of the StepWatch outcomes in the exercise group. Subjective improvements in walking were noted by a greater proportion of the exercise group than the control group at the post-intervention testing session(p=0.042) but no changes were found in the self-report measures, RMI and PADS. The gains seen in the exercise group immediately following the intervention were not maintained at three months with a drop off in the 6MWT towards baseline values.

The exercise and control groups had significantly different gait speed (p=0.038) and scores on the RMI (p=0.025) at the three-month follow-up. These differences represented a greater decline in the control group compared to the exercise group for both outcome measures.

Discussion

This study has found that exercise-based rehabilitation led to early improvements in gait endurance but did not change the amount or rate of usual walking performance, as measured by the StepWatch Activity Monitor. Furthermore, gains made after the intervention were not retained three months later.

Previous trials of rehabilitation exercise programmes in stroke have largely demonstrated improvements in clinical measures of up to 33%,[8-11] but have not looked at carry-over of these gains into an individual's usual environment. This study is novel as we have recorded a measure of usual walking performance in addition to standard clinical walking outcomes. No change could be demonstrated in any of the StepWatch outputs in the participants' usual environment despite clinical improvements. These findings mirror the results of a 2004 study of 18 subjects with chronic heart failure, in which improvements in clinical measures following an aerobic training programme were not accompanied by a change in physical activity in the participants' usual environments.[40]

The majority of the participants in our study reported their walking improved and that they enjoyed the circuit classes and would have liked the opportunity to continue beyond the completion of the trial. This interest in exercise is consistent with the findings of a recent survey of individuals with stroke.[41] Sixty-nine percent of respondents did not exercise as much as they would like and 84% reported they would be interested in an exercise programme if one were available. However, despite the participants' enthusiasm and belief that their

walking had improved, this study shows that there was no change in usual walking activity.

Exercise training has been shown to consistently increase overall physical activity levels in previously sedentary but healthy young adults.[42-44] Non-training activity (usual activity that occurs at any other time than during training) remains constant[44] but the added training activity results in an increase in overall physical activity. Substantial gains in the physical activity index from a pre-training level of 1.6 for both men and women to 1.9 for women and 2.4 for men have been shown, where 1.5 is defined as light, 1.8 as moderate and 2.1 as high levels of activity.[43] In contrast, the overall physical activity levels of healthy elderly subjects do not change when they participate in an exercise training programme.[45-47] Instead, non-training physical activity is reduced, fully compensating for the increased exercise-related activity. In the current study, the median age of participants was 71.5 years. Thus participants in the exercise group may have acted in a similar manner to healthy elderly subjects by decreasing their non-training activity for the duration of the exercise programme. Future studies could investigate the possible confounding effect of this change in behaviour by monitoring usual activity during and after the exercise programme.

It is also feasible that participants in this trial were already performing near their functional reserve.[48, 49] This suggestion is supported by the relatively high mean steps/day of the exercise group (6679 ± 3792), at baseline in relation to other studies in stroke (1389 ± 798 steps/day;[27] 2821 ± 1527 steps/day[50]). This

number of steps is within normal limits for healthy older adults (6565 ± 1530 steps/day[51]). If participants were already near or at their peak walking activity in usual environments, then further increases of usual walking activity are less achievable. Future studies could use mean number of steps/day as an additional criterion for study inclusion or exclusion.

The gains in the 6MWT made by the exercise group were not retained at the follow up. In addition, the control group showed a greater decline in gait speed and the RMI than the exercise group at follow-up. The finding of loss of function over time for individuals with chronic stroke is disappointing, but is consistent with previous studies which have shown that improvements in gait speed are not sustained in the longterm. [11, 52] Arguably, clinical gains that are not accompanied by a change in usual performance are not likely to be lasting.

This study is limited by the relatively small subject numbers, although there was sufficient power to detect a relevant change in the StepWatch outputs. The characteristics of our participants may limit the findings to a wider generalisation to other people with stroke, as this sample appeared to be higher functioning in terms of gait speed and total steps per day than reported in previous studies.

The results of this study raise a number of clinical questions about whether rehabilitation in a clinical setting is optimal for changing usual walking performance. Although the circuit stations included task-oriented balance and gait tasks and attempted to simulate environments encountered outside the clinic (e.g. obstacle course, fast walking), it was, nevertheless, a safe clinical

environment, which may not adequately represent the complexity of walking in community settings. [53, 54] Furthermore, practice to encourage carry over to other environments was not specifically included in the exercise classes. Rehabilitation might be more successfully delivered in usual environments, where practice of real world activities is more meaningful, thus enhancing carry-over. Future studies should consider whether rehabilitation needs to occur in community environments in order to improve usual walking performance. In addition, a gait endurance component was not included in the exercise circuit, which, if included, may have promoted carry over to the number of steps taken per day.[27] However, there are likely to be other influences, such as personal and environmental factors which may also impact the amount of usual walking.[55, 56]

Conclusions

Circuit-based rehabilitation leads to an early improvement in gait endurance but does not change the amount or rate of usual walking performance. Clinical gains made by the exercise group were lost three months later. It is likely that there are other factors, besides physical performance that may have an influence on physical activity levels in this population group.

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392 Appendix

393 1. Exercise programme stations and progressions

394 2. Control group sessions

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396 References

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Suppliers

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566 Figure 1. Flow of participants through trial
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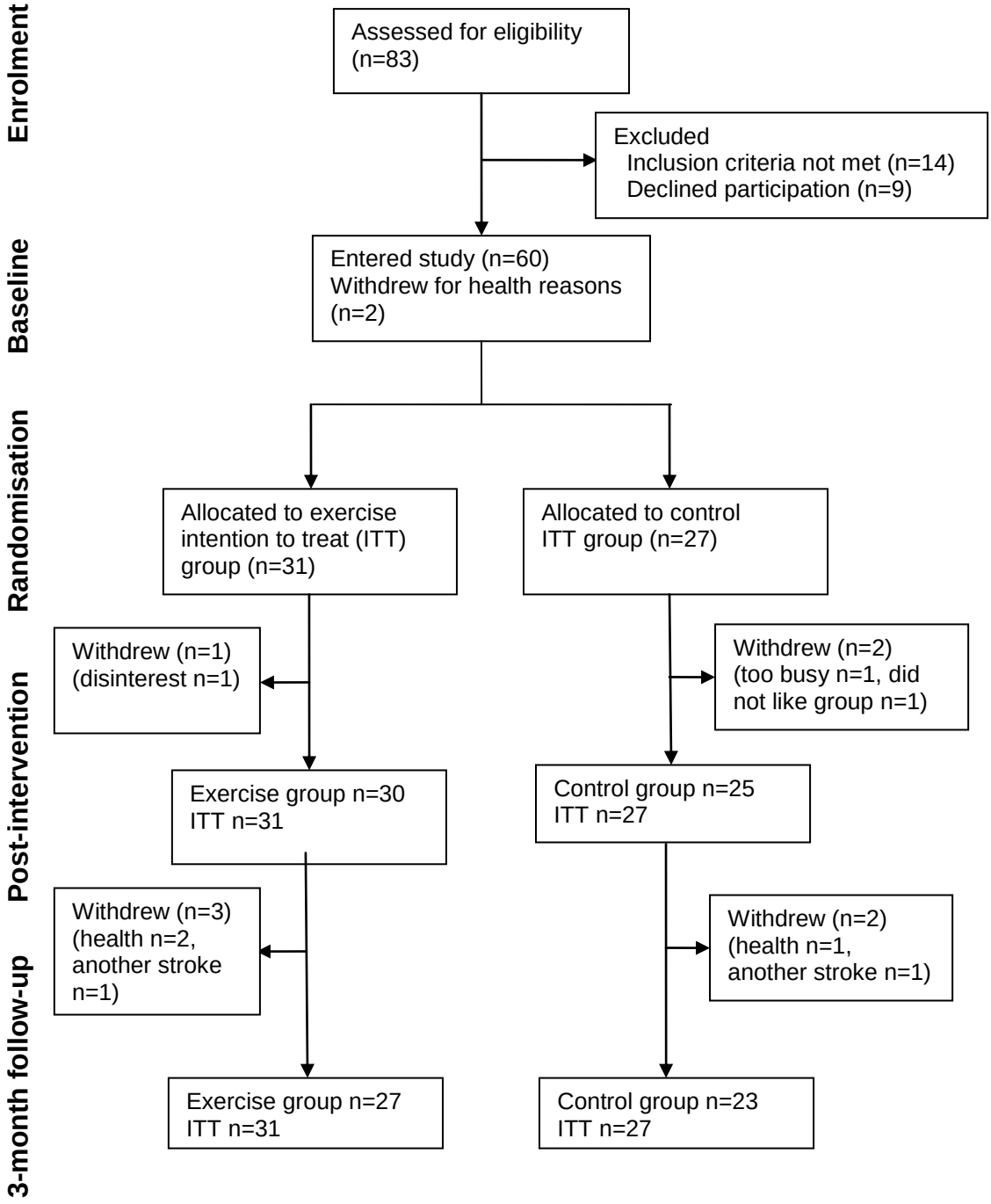
Enrolment
Assessed for eligibility (n=83)
Excluded
Inclusion criteria not met (n=14)
Declined participation (n=9)
Baseline
Entered study (n=60)
Withdrew for health reasons (n=2)
Randomisation
Allocated to exercise intention to treat (ITT) group (n=31)
Allocated to control ITT group (n=27)
Post-intervention
Withdrew (n=1) (disinterest n=1)
Withdrew (n=2) (too busy n=1, did not like group n=1)
Exercise group n=30 ITT n=31
Control group n=25 ITT n=27
3-month follow-up
Withdrew (n=3) (health n=2, another stroke n=1)
Withdrew (n=2) (health n=1, another stroke n=1)
Exercise group n=27 ITT n=31
Control group n=23 ITT n=27

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Table 1. Baseline Characteristics of Each Group

Variable	**Control (n-27)**	**Experimental (n=31)**	**p-value**
Demographics			
Median Age (range) (years)	71.0 (44.0-86.0)	76.0 (39.0-89.0)	0.755 [a]
Sex			
Male	13 (48%)	19 (61%)	0.315 [b]
Female	14 (52%)	12 (39%)	
Race			
NZ/European	21 (78%)	26 (84%)	0.390 [c]
Maori	1 (4%)	3 (10%)	
Pacific Islander	2 (7%)	0 (0%)	
Other	3 (11%)	2 (6%)	
Assistive Device			
Walker	5 (19%)	2 (6%)	0.229 [c]
Crutch	1 (4%)	0 (0%)	
Quad cane	2 (7%)	2 (6%)	
Straight cane	8 (30%)	6 (19%)	
None	11 (41%)	21 (68%)	
Stroke Characteristics			
Median Onset (range) (years)	5.8 (0.5-18.7)	3.33 (0.6-13.3)	0.242 [a]
Location			
Right hemisphere	14 (52%)	20 (65%)	0.425 [c]
Left hemisphere	12 (44%)	11 (35%)	
Brain stem/other	1 (4%)	0 (0%)	
Physical Functioning Index of SF-36			
Median (range)	17.0 (10.0-28.0)	19.0 (12.0-26.0)	0.360 [a]

[a] Wilcoxon-Mann-Whitney Test

[b] Chi-Square Test

[c] Fisher's Exact Test

Table 2. Means, Standard Deviations and Coefficients of Variation for Baseline Measures by Intervention Group

Baseline Measure	**Control (n=27)**	**Exercise (n=31)**	**p-value** [a]	**Control**	**Exercise**
	Mean ± SD			**%CV**	
Clinical outcome measures					
Gait speed (m/s)	0.62±0.27	0.76±0.30	0.069	7.93%	7.77%
Gait endurance (6MWT) (m)	201±99	263±110	0.028	9.48%	7.91%
RMI (median, range)	13.5 (9.0-15.0)	14.0 (6.5-15.0)	0.282 [b]	5.14%	3.49%
ABC	6.03±1.68	6.86±2.03	0.097	12.16%	8.11%
PADS	63.6±77.0	75.2±57.5	0.516	21.30%	34.67%
StepWatch output					
Mean steps/day (steps)	4616±2618	6679±3792	0.021	14.86%	11.60%
Peak activity index (steps/min)	52.0±15.9	66.6±23.3	0.008	8.43%	6.57%
Max 1 (steps/min)	76.6±19.1	89.6±21.8	0.019	6.52%	4.97%
Percentage time inactive (%)	84.1±7.0	81.6±8.3	0.235	2.20%	2.45%

[a] Analysis of Variance (ANOVA) for unbalanced designs, unless specified

[b] Wilcoxon-Mann-Whitney Test

%CV = coefficient of variation between the two baseline testing sessions

Table 3. Observed and Adjusted Means for Outcome Measures by Intervention Group

Outcome Measure	Group	Baseline	Post –Intervention		3 Month Follow-up	
		Observed mean±sd	Observed mean±sd	Adjusted mean±SE	Observed mean±sd	Adjusted mean±SE
Gait speed (m/s)	Control (n=27)	0.62±0.27	0.63±0.25	0.69±0.02	0.63±0.25	0.66±0.02
	Exercise (n=31)	0.76±0.30	0.79±0.28	0.73±0.02	0.77±0.26	0.72±0.02
	ANCOVA[a]			p=0.090		p=0.038
Gait endurance (6MWT) (m)	Control (n=27)	201±99	200±99	233±6.5	195±104	229±8.1
	Exercise (n=31)	263±110	282±117	253±6.0	277±125	247±7.6
	ANCOVA			p=0.030		p=0.116
RMI[b]	Control (n=27)	13.5, 9.0-15.0	14.0, 10.0-15.0	0.0, -5.0-2.0	14.0, 7.0-15.0	0.0, -4.0-1.5
	Exercise (n=31)	14.0, 6.5-15.0	14.0, 9.0-15.0	0.0, -2.0-4.0	14.0, 5.0-15.0	0.0, -2.5-1.5
	Wilcoxon Signed Rank-Sum Test			p=0.121		p=0.025
ABC	Control (n=27)	6.03±1.7	6.42±1.7	6.78±0.20	6.62±1.7	6.99±0.22
	Exercise (n=31)	6.86±2.0	7.36±1.9	7.05±0.19	7.12±2.1	6.80±0.20
	ANCOVA			p=0.339		p=0.538
PADS	Control (n=27)	63.6±77.0	60.9±67.2	65.8±8.2	62.2±72.5	66.6±10.5
	Exercise (n=31)	75.2±57.5	77.8±55.7	74.2±7.6	82.1±72.8	78.2±9.8
	ANCOVA			p=0.413		p=0.427
Mean steps/day (steps)	Control (n=27)	4616±2618	4370±2994	5359±390.1	4403±2961	5360±292.9
	Exercise (n=31)	6679±3792	6666±3966	5804±362.8	6393±3429	5559±272.5
	ANCOVA			p=0.418		p=0.629
Peak activity index (steps/min)	Control (n=27)	52.0±15.9	49.0±17.5	55.5±2.3	51.5±20.5	58.2±2.4
	Exercise (n=31)	66.6±23.3	67.1±22.8	61.5±2.1	63.7±21.5	57.8±2.2
	ANCOVA			p=0.071		p=0.918
Max 1 (steps/min)	Control (n=27)	76.5±19.1	75.2±20.5	81.7±1.9	75.6±22.2	82.0±2.2
	Exercise (n=31)	89.6±21.8	90.7±21.9	85.0±1.7	87.7±21.9	82.1±2.1
	ANCOVA			p=0.205		p=0.965
Percentage of time inactive (%)	Control (n=27)	84.1±7.0	84.4±8.2	83.1±0.8	84.7±7.3	83.6±0.5
	Exercise (n=31)	81.6±8.3	81.9±8.3	83.0±0.8	82.0±7.4	83.0±0.5
	ANCOVA			p=0.926		p=0.422

[a] Analysis of Covariance (ANCOVA) with baseline measure as covariate, unless specified

[b] Observed means for RMI are displayed as median, range. Adjusted means for RMI are displayed as median change from baseline, range

sd=standard deviation; SE=standard error

Appendix 1. Content and progressions of circuit exercise programme

Allow 2 minutes at each station (excluding changeover time)

Exercise Station	**Progressions**
1. sit to stand	Increase speed until can complete 30, then decrease seat height.
2. self sway	Start near wall for support, sway from ankles forwards and backwards, progress by increasing amplitude, then progress to standing away from wall.
3. standing balance	Stand in parallel bars with feet close together, try and balance as long as possible. Progress by adding crossed arms and turns of upper body. Progress further to standing on one leg.
4. step ups	Start with low step, progress by increasing height of step.
5. balance beam	Step over balance beam leading with alternate feet. Progress by increasing speed. Progress further to cross-overs.
6. standing hamstring curl	Progress weight and repetitions.
7. tandem walk	Walk with feet touching line on floor. Progress to heel-toe. Progress further by decreasing speed, looking forward, crossing arms.
8. swiss ball squats	Progress depth of squat until thighs parallel with ground; add hold which can be progressed by increasing time, progress further by adding weights to hands.

9. tandem stance	Start with hands on wall for balance; progress base of support until heel-toe, progress to centre of room, progress to arms crossed.
10. calf raise	Start with double calf raise; progress speed, progress to single calf raise, progress to jumps.
11. backwards walk	Start near wall for balance, progress to centre of room, progress to shuttle runs
12. lunges	Start holding on for support, progress depth of lunge, progress number on each leg, progress to no support.
13. side leg lifts	Progress weight and repetitions.
14. marching in place	Progress to marching with a weight, marching with no hand support, marching on mini tramp.
15. obstacle course	progress by increasing speed, varying obstacles

Finish with 5 minutes stretching of major leg muscle groups

Appendix 2. General objectives for social and educational programme sessions

1. Introductory Session and Adaptive Equipment Display.

- Introduce participants to the groups and provide information on the types of groups that we will be running over the next 4 weeks.
- Provide participants with relevant and useful information for everyday functioning.
- Give participants an opportunity to share ideas and methods of carrying out ADL's and to learn from each other.
- To have a relaxed and open atmosphere and one in which participants will enjoy themselves.

2. Bowls Group

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group, and offer each other support.
- Play a game which may be familiar to some.
- Provide a new experience for those who have not played bowls before.

3. Quiz Group

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group, and offer each other support.
- Provide a session which involves some intellectual stimulation and enjoyment.
- Everybody will be able to participate in the group and contribute to their teams.

4. Falls Prevention and Energy Conservation Group

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group and offer each other support.
- Provide education and information about fatigue management, energy conservation and falls prevention which will be useful and practical for participants to use in their everyday lives.

5. Board games group

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group, and offer each other support.
- Offer participants a selection of board games to play, they may choose to play in small groups or pick a game to play all together.
- Provide an opportunity for participants to contribute equally to the group.

6. Bowls Group

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group, and offer each other support.
- Play a game which all are familiar with.

7. Prevention of Secondary Stoke

- Continue to build a familiar relaxed and friendly social atmosphere.
- Provide participants with an opportunity to raise concerns or to discuss the previous group, and offer each other support.
- Provide and opportunity to discuss stoke and lifestyle changes which may help in improving health and possibly prevent further strokes in the future.

8. Café Outing

- Closure of the social group.
- Provide and opportunity for participants to feedback and reflect on the group and how they have benefited or otherwise from the group.