

- 1 Usual walking performance following rehab
- 2
- 3 Circuit-based rehabilitation improves gait endurance but not usual walking
- 4 activity in chronic stroke: a randomised clinical trial.
- 5

6 Abstract

7

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

11 **Design:** Single blind randomised controlled trial

12 **Setting:** Rehabilitation clinic

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

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

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

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

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

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

40

41 Key words: Rehabilitation; stroke; walking;

42

43 **Introduction**

44

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

49

50 Walking remains a major focus of physical therapy programmes,⁷ although the
51 specific components of training that optimise walking recovery are less certain.

52 Task oriented gait training, including walking in all directions, over different
53 surfaces, obstacles, inclines and steps, consistently results in improved clinical
54 measures of gait, particularly self selected gait speed and endurance.⁸⁻¹⁴

55

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

63

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

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

71

72 **Methods**

73

74 This is a prospective, randomised, single-blind, attention-controlled clinical trial
75 of circuit-based rehabilitation in adults at least six months after stroke.

76 Participants were a convenience sample recruited through the Stroke
77 Foundation of New Zealand, stroke clubs and the local hospital stroke service.
78 Information sheets about the study were provided to potential candidates who
79 were invited to contact the principal investigator if they wished to participate.

80 The study was approved by the Regional Ethics Committee and each
81 participant provided informed consent. Procedures were conducted in
82 accordance with the Declaration of Helsinki.

83

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

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

96

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

101

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

116

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

127

128 Outcome Measures

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

137

138 The monitor was initially calibrated and attached to the lateral side of the ankle
139 of the non-paretic leg with a strap or cuff. The monitor has an infrared light that
140 flashes with every step, which were matched to a manual count of steps during
141 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 commonly³³ 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

167

168 The Rivermead Mobility Index (RMI) was used to capture self reported mobility.

169 The RMI is a self report of ability to perform up to 15 mobility items (six

170 specifically related to walking), with answers given of either “yes” or “no”. The

171 RMI reflects a breadth of walking conditions, such as walking over uneven

172 surfaces and walking outside that are not evaluated by the commonly used

173 timed walking tests.³³ The highest score of 15 indicates an ability to climb up

174 and down four steps with no rail and run 10 metres.

175

176 The Physical Activity and Disability Scale (PADS) was used to determine the

177 level of activity performed by an individual. The PADS is specifically designed to

178 reflect activities potentially performed by individuals with disabilities.³⁷

179 Satisfactory reliability (ICC = 0.85) and validity are reported by the developers

180 of the scale.³⁸

181

182 Following the post-intervention testing session, each participant was asked

183 whether they thought there had been any change in their walking over the

184 intervention period and/or while they were wearing the StepWatch, and, if so,

185 whether they thought the change related to quality, speed or quantity of

186 walking.

187

188 Outcome assessment was performed by an independent physiotherapist

189 blinded to treatment assignment. Participants were not blinded, as they were

190 aware of their own group allocation, which was revealed after the second

191 testing session. Participants were instructed not to discuss group allocation with

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

195

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

201

202 Statistical Analysis

203 Baseline Data: Tests for normality were done for all continuous variables.

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

213

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

217 of covariance (ANCOVA) was used to test for intervention group differences
218 with the baseline measure as the covariate. Wilcoxon Signed Rank-Sum test
219 was used to assess whether there were intervention group differences at post-
220 intervention and 3-months follow-up, for non-parametric outcomes..
221 Calculations were performed using SAS^c .

222

223 The power calculation was based on data from Michael et al,²⁶ who reported
224 2837 ± 1503 mean steps/day in 50 participants with stroke. A 40% increase in
225 mean steps/day was chosen as the smallest relevant difference, as this level of
226 change reflects the smallest amount not attributable to normal daily variation.³⁰
227 A sample size of 25 participants would therefore have greater than 90% power
228 to detect a 40% within-group change in mean steps/day, assuming a correlation
229 coefficient of at least $r=0.4$, and a significance level of 0.05. A sample size of
230 25 participants in each group has 80% power to detect a 42% between-group
231 change in mean steps/day, with a significance level of 0.05

232

233 **Results**

234

235 Sixty participants (median 71.5 years old (range 39-89) and median 3.9 years
236 following stroke (range 0.5-18.7 years) were enrolled in the study between June
237 2007 and February 2008. However, two participants withdrew before
238 randomisation leaving 58 individuals who are the subject of this study (Figure
239 1). Thirty-one participants were randomised to the exercise group and 27 to the
240 control group. The median score on the physical functioning index of the 36
241 Item Short Form Health Survey was 17 for the control group and 19 for the

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

248

249 Of the 55 participants who completed the interventions, adherence to both
250 groups was high with participants attending an average of 11.1 ± 1.7 hours (7.4
251 ± 1.2 sessions) in the control group and 10.8 ± 1.6 hours in the exercise group,
252 both out of a possible 12 hours. Unmasking of the independent assessor
253 occurred in the case of three participants, who inadvertently stated or implied
254 their group allocation.

255

256 *Baseline*

257 Coefficients of variation calculated from the two baseline measures ranged from
258 5.14% for the RMI to 21.30% for the PADS in the control group and 3.49% for
259 the RMI to 34.67% for the PADS in the exercise group (Table 2). With the
260 exception of the PADS for each group, the coefficients of variation were all
261 under 15% and were under 10% for the 6MWT and gait speed.

262

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

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

270

271 *Post-intervention*

272 Table 3 shows the observed outcome scores at baseline, post intervention and
273 at three months follow-up and the adjusted means, with the baseline values as
274 covariates, at post intervention and follow-up. Immediately following the
275 intervention, the exercise group showed a significantly greater distance for the
276 6MWT compared to the control group ($p=0.030$) (Table 3). However, this did not
277 translate into increased activity in the participants' usual environments with no
278 changes in any of the StepWatch outcomes in the exercise group. Subjective
279 improvements in walking were noted by a greater proportion of the exercise
280 group than the control group at the post-intervention testing session ($p=0.042$)
281 but no changes were found in the self-report measures, RMI and PADS. The
282 gains seen in the exercise group immediately following the intervention were
283 not maintained at three months with a drop off in the 6MWT towards baseline
284 values.

285

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

290

291 **Discussion**

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

297

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

309

310 The majority of the participants in our study reported their walking improved and
311 that they enjoyed the circuit classes and would have liked the opportunity to
312 continue beyond the completion of the trial. This interest in exercise is
313 consistent with the findings of a recent survey of individuals with stroke.⁴¹ Sixty-
314 nine percent of respondents did not exercise as much as they would like and
315 84% reported they would be interested in an exercise programme if one were
316 available. However, despite the participants' enthusiasm and belief that their

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

319

320 Exercise training has been shown to consistently increase overall physical
321 activity levels in previously sedentary but healthy young adults.⁴²⁻⁴⁴ Non-training
322 activity (usual activity that occurs at any other time than during training) remains
323 constant⁴⁴ but the added training activity results in an increase in overall
324 physical activity. Substantial gains in the physical activity index from a pre-
325 training level of 1.6 for both men and women to 1.9 for women and 2.4 for men
326 have been shown, where 1.5 is defined as light, 1.8 as moderate and 2.1 as
327 high levels of activity.⁴³ In contrast, the overall physical activity levels of healthy
328 elderly subjects do not change when they participate in an exercise training
329 programme.⁴⁵⁻⁴⁷ Instead, non-training physical activity is reduced, fully
330 compensating for the increased exercise-related activity. In the current study,
331 the median age of participants was 71.5 years. Thus participants in the exercise
332 group may have acted in a similar manner to healthy elderly subjects by
333 decreasing their non-training activity for the duration of the exercise
334 programme. Future studies could investigate the possible confounding effect of
335 this change in behaviour by monitoring usual activity during and after the
336 exercise programme.

337

338 It is also feasible that participants in this trial were already performing near their
339 functional reserve.^{48, 49} This suggestion is supported by the relatively high mean
340 steps/day of the exercise group (6679 ± 3792), at baseline in relation to other
341 studies in stroke (1389 ± 798 steps/day;²⁷ 2821 ± 1527 steps/day⁵⁰). This

342 number of steps is within normal limits for healthy older adults (6565 ± 1530
343 steps/day⁵¹). If participants were already near or at their peak walking activity in
344 usual environments, then further increases of usual walking activity are less
345 achievable. Future studies could use mean number of steps/day as an
346 additional criterion for study inclusion or exclusion.

347

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

355

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

361

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

367 environment, which may not adequately represent the complexity of walking in
368 community settings.^{53, 54} Furthermore, practice to encourage carry over to other
369 environments was not specifically included in the exercise classes.

370 Rehabilitation might be more successfully delivered in usual environments,
371 where practice of real world activities is more meaningful, thus enhancing carry-
372 over. Future studies should consider whether rehabilitation needs to occur in
373 community environments in order to improve usual walking performance. In
374 addition, a gait endurance component was not included in the exercise circuit,
375 which, if included, may have promoted carry over to the number of steps taken
376 per day.²⁷ However, there are likely to be other influences, such as personal
377 and environmental factors which may also impact the amount of usual
378 walking.^{55, 56}

379

380 Conclusions

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

386

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391

392	Appendix
393	1. Exercise programme stations and progressions
394	2. Control group sessions
395	

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397

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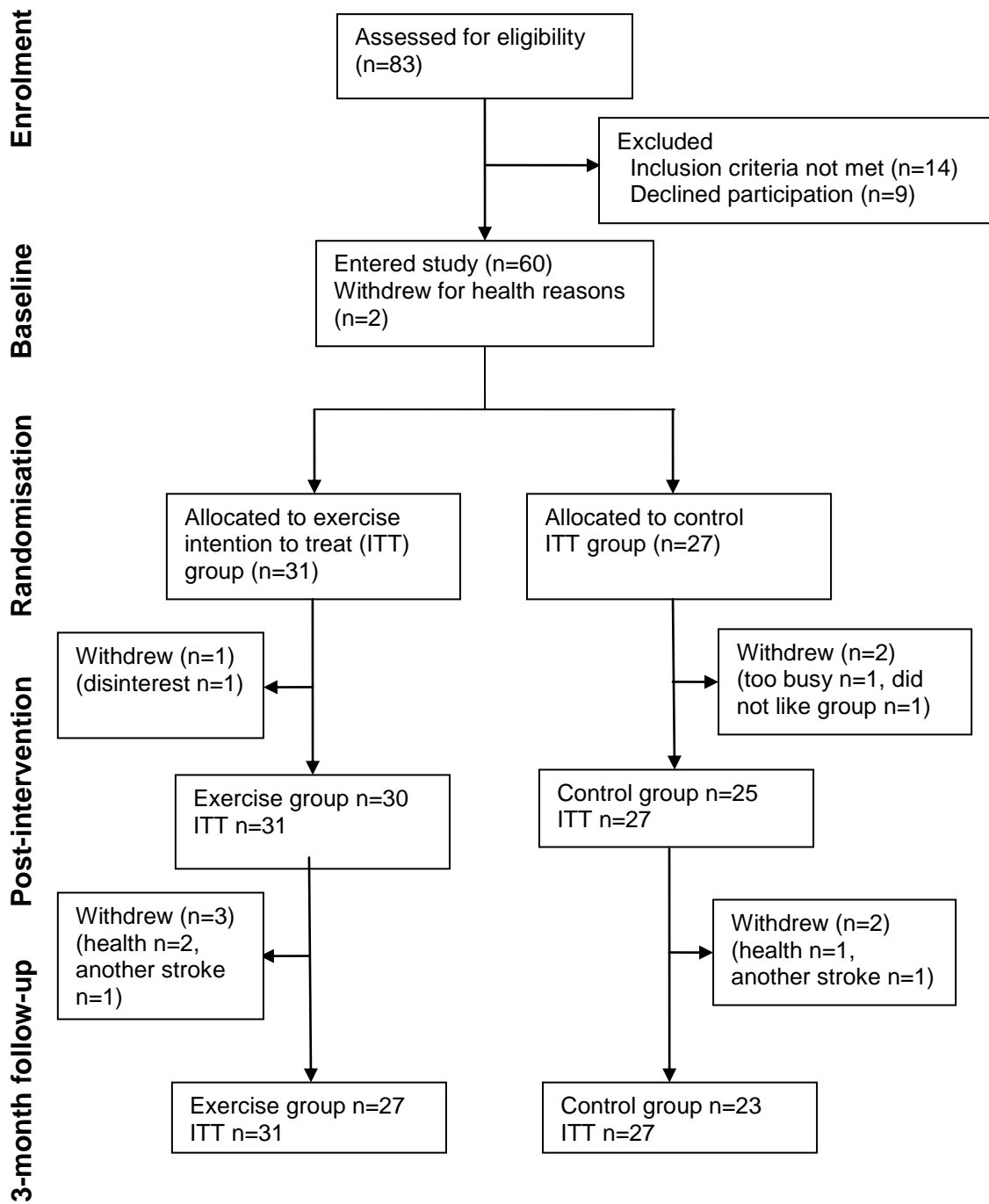
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566 Figure 1. Flow of participants through trial
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Table 1. Baseline Characteristics of Each Group

Variable	Control (n=27)	Experimental (n=31)	p-value
<i>Demographics</i>			
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%)	
<i>Stroke Characteristics</i>			
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%)	
<i>Physical Functioning Index of SF-36</i>			
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	
<i>Clinical outcome measures</i>					
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%
<i>StepWatch output</i>					
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 Stroke

- 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 an opportunity to discuss stroke 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 an opportunity for participants to feedback and reflect on the group and how they have benefited or otherwise from the group.