A community-based group exercise program for persons with chronic stroke

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Abstract

PURPOSE—The purpose of this study was to evaluate the physical and psychosocial effects of an 8-week community-based functional exercise program in a group of individuals with chronic stroke.

METHODS—Twenty-five subjects (mean age 63 years) participated in a repeated measures design which evaluated the subjects with two baseline assessments one month apart, one post-intervention assessment, and one retention assessment one month post-intervention. Physical outcome measures assessed were the Berg Balance Test, 12 minute walk test distance, gait speed and stair climbing speed. Psychosocial measures assessed were the Reintegration to Normal Living Index (RNL) and Canadian Occupational Performance Measure (COPM). The 8-week training consisted of a 60 min, 3 times per week group program which focused on balance, mobility, functional strength and functional capacity. The program was designed to be accessible by reducing the need for costly one-on-one supervision, specialized settings and expensive equipment.

RESULTS—Improvements from the exercise program were found for all physical measures and these effects were retained one-month post-intervention. Subjects with lower function improved the most relative to their initial physical status. Significant effects were found for the COPM, but not the RNL Index, however, subjects with lower RNL improved the most relative to their initial RNL score.

CONCLUSION—A short-term community-based exercise program can improve and retain mobility, functional capacity and balance and result in a demonstrable impact upon the performance of activities and abilities that were considered meaningful to the subjects. Implementation of such community-based programs have potential for improving activity tolerance and reducing the risk for secondary complications common to stroke (e.g., falls resulting in fractures and cardiac events).

Keywords

cerebrovascular accident; physical activity; disability; function; walk

INTRODUCTION

Over fifty thousand Canadians suffer from stroke each year making it the number one cause of neurological disability in Canada today (23) and a leading cause of disability in the community (19). Ninety percent of stroke survivors have some functional disability with mobility being the major impairment (21). Although some individuals with stroke will have received some rehabilitation during the acute and sub-acute phase, rarely does rehabilitation extend beyond one year post-injury due to the belief that functional recovery has plateaued by this time (42). Impairments resulting from stroke, such as muscle weakness, pain, spasticity and poor balance, in addition to the lack of accessible and appropriate community-based exercise programs can lead to reduced tolerance to activity, further sedentary lifestyle, and additional declines in function and disability status (32).

Activities which promote mobility and fitness are imperative for the prevention of further pathological events (e.g., falls resulting in fracture, recurrent strokes or cardiac events). Stroke is one of the top risk factors for incurring fractures as a result of a fall in older adults; Kanis et al. (24) analyzed 16.3 million hospitalizations due to fractures and reported a 7-fold hip fracture risk for individuals with stroke. In fact, the incidence of falls has been reported to be as high as 73% of individuals with stroke falling within six months following hospital discharge to home with an average of 3.4 falls per person during this six month time period (18). In addition, cardiovascular disease is the leading prospective cause of death in chronic stroke. Inactivity and low cardiovascular fitness, a major occurrence in persons with stroke, is one of the modifiable risk factors associated with cardiovascular disease.

In the past, intensive training in persons with stroke has been controversial due to the belief that strenuous activity would increase spasticity and reinforce abnormal movement (5). However, recent evaluation of intensive exercise programs has not found any evidence of an increase in spasticity (39).

Intensive treadmill protocols (30, 34, 37) are a recent addition to stroke rehabilitation and have resulted in improvements in gait and aerobic capacity, however, Smith et al. (38) found no significant improvements in reactive balance using an endurance treadmill protocol and suggested that functional or task-specific training may be needed to improve balance. Duncan et al. (14) also reported no significant improvements for the Berg Balance score using a randomized controlled home-based individual exercise program (strengthening and walking program). Functional balance may be difficult to improve due to the varied tasks and movements under which balance is required. The one exception was a non-controlled pilot study by Weiss et al. (43) which reported a 12% improvement in the Berg Balance Score for 7 individuals with stroke using a one-to-one high intensity strengthening program. However, Kim et al. (26) recently undertook a double-blind randomized controlled trial of strength training in chronic stroke found no carry-over into functional tasks and these authors emphasized the need for functional task-based practice.

Intensive rehabilitation programs for individuals with stroke have traditionally involved a one-to-one client-therapist ratio due to the close supervision required when challenging balance in these individuals, in addition to the necessary monitoring when taxing their cardiovascular function. However, given the current limited rehabilitation resources, it would be ideal to develop safe and effective community-based group exercise programs which are accessible to larger numbers of individuals. There is a clear and impressive void in the current literature which evaluates community-based group exercise programs for individuals with stroke and only three studies have examined such programs. Rimmer et al. (37) undertook an intensive 12-week community-based group training program (seven staff to 18 clients) which resulted in improvements in peak VO_2 , strength, and back flexibility, but did not measure or train balance. A recent controlled pilot study which evaluated an 8-week circuit training program found improvements in walking speed, six minute walk distance, in addition to weight-bearing ability through the affected limb for the five experimental subjects (supervised by two physical therapists) compared to the four control subjects (12). Teixeira-Salmela et al. (39) found improvements in gait and stair climbing speed, in addition to muscle strength from a 10-week muscle strengthening and physical conditioning program for 13 individuals with stroke. No studies to date have assessed the effect of a community-based group exercise program on both balance and functional capacity in individuals with stroke, and in addition, the retention of these effects has never been evaluated.

The purpose of this study was to evaluate a community-based group exercise intervention on both balance and functional capacity, two functions which are severely compromised in persons with stroke and can lead to devastating secondary complications. We evaluated the effects of an 8-week group exercise intervention on balance, walking ability and functional capacity and the retention of these effects one month post-intervention. Lastly, the psychosocial effects of exercise are infrequently evaluated in stroke, despite the well-documented high incidence of clinical depression in this population (4, 10) and the knowledge that exercise can have substantial benefits to one's well-being (11, 25). Therefore, we also evaluated the effect of the exercise intervention on measures of health-related quality of life.

METHODS

Research Design

A single group, repeated measures design was used for this study. Subjects underwent a baseline assessment (T1) followed by a second baseline assessment (T2) four weeks later to determine the stability of the outcome values. Following this second baseline assessment, subjects participated in an 8-week intensive group exercise program focused on balance, strength and functional capacity. Following the 8-week intervention, subjects underwent the first post-intervention assessment (T3). A second post-intervention assessment was undertaken four weeks after the first post-intervention test (T4) to determine retention effects.

Subjects

Subjects were recruited from the community (e.g., advertisements placed in the local newspapers and community centres). Ethics approval was acquired from the local university and hospital review boards. In accordance with the university and hospital policy and to protect the rights of the subjects, informed written consent was received from all subjects prior to participating in this study. Inclusion criteria were:

- be a minimum of one year post-stroke
- present hemiparesis secondary to one cerebrovascular accident
- positive answers on a modified Par-Q Test
- study participation approval by their family physician who had been provided a letter which described the program and exclusion criteria
- able to provide informed consent
- follow one and two step commands
- have an activity tolerance of 60 minutes with rest intervals
- able to walk 10 metres with rest intervals with or without assistive devices

Exclusion criteria:

- musculoskeletal or neurological conditions in addition to the stroke
- uncontrolled hypertension, congestive heart failure, or atrial fibrillation
- scored less than 24 on the Folstein Mini-Mental Test (16)

Outcome Measures

For each of the four assessment times (two baselines and two post-interventions), the following outcomes were measured: 1) Berg Balance Test (2), 2) 12 minute walk test distance (31), 3) self-paced gait speed, 4) fast-paced (as fast as you can walk safely) gait speed, 5) self-paced stair climbing speed, 6) fast-paced (as fast as you can climb safely) stair climbing speed, and 7) 11-item Reintegration to Normal Living Index (RNL Index). All testing was undertaken by evaluators who did not know the subjects and were not involved in the training intervention. For all measures and test sessions, both the evaluators and subjects did not have information regarding the subject's evaluation from the previous test session.

The Berg Balance Test consists of 14 tasks which challenge balance while sitting, standing or stepping (minimum score = 0 and maximum score = 56 with higher scores indicating better balance performance) and has been shown to be a valid and reliable measure and related to fall risk (2). The 12 Minute Walk Test (12MWT) is a reliable measure of functional capacity in persons with stroke (15) as defined by the extent in which a person can increase exercise intensities and maintain those increased levels (9). Gait speed has been shown to be a reliable measure and related to the stage of recovery, lower extremity strength and clinical tests of motor function in stroke (36). Gait speed was calculated from the mean of three trials using the distance and time measured by infrared emitting diodes (Optotrak,

Northern Digital) attached to the lateral malleoli and toe for the middle four meter section (i.e., representative window of constant gait speed) of a 10-meter walkway. The mean of two trials for the time to climb up four stairs was assessed and has been shown to be reliable in healthy adults (33).

The RNL Index is a self-report measure which has been tested in stroke survivors that asks individuals to rate their satisfaction on 11 items regarding their physical lives (e.g., “I move around my community as I feel is necessary”), emotional lives (e.g., “I feel that I can deal with life events as they happen”) and social lives (e.g., “I participate in social activities with my family, friends and/or business acquaintances as is necessary or desirable to me”) (46). The score is normalized to 100 with a greater score representing a higher level of satisfaction. Excellent internal consistency (Chronbach’s $\alpha > 0.90$) has been reported for the RNL for 80 individuals whose health problems included heart disease, neurological conditions, musculoskeletal conditions and tumors (46). In addition, the RNL has been shown to be responsive to changes in the clinical status of patients with stroke (3).

The Canadian Occupational Performance Measure (COPM) was used only at the second baseline assessment and the first post-intervention assessment. The COPM is a valid and reliable individualized, outcome instrument designed to detect change in self-perception of occupational performance over time (28). Subjects are asked to identify their own problems in the areas of self-care (e.g., difficulty bathing), productivity (e.g., no longer able to work outside the home) and leisure (e.g., difficulty reading). Subjects then rate their 1) perceived performance and 2) perceived satisfaction on a 10 point scale for each of the five most important problems. Ratings for the five problems are summed and divided by 5 for a Performance Score and a Satisfaction Score (each with a minimum score of 1 and maximum score of 10 with higher scores indicating better perceived performance or higher levels of satisfaction). As there was only one baseline measure of the COPM, the stability of this measure prior to the intervention was not assessed in this study. However, others have reported good test-retest reliability (Intraclass correlation coefficients > 0.80) for this particular outcome measure in individuals in outpatient rehabilitation settings (8, 29).

Intervention

In this study we used only equipment generally available in community centers (e.g., chairs, ankle weights and stackable risers/steppers). The only safety modification was a non-slip pad to the bottom of each chair leg. The functional exercise program was an 8-week, one hour program three times per week and comprised light aerobic warm-up (e.g., marching on the spot, arm swinging), stretching (e.g., calf stretches, hamstring stretches), functional lower extremity strengthening (e.g., repetitive rise from a low chair, repetitive rise on toes), functional lower extremity strengthening with light weights (e.g., marching with 0.5 kg ankle weights to improve hip flexor muscles), balance and weight-shifting (e.g., lunges in different directions), aerobic stepping with steppers, a walking circuit (Figure 1) and cool-down/stretching. Exercises in this program were designed with grade increments to meet the capabilities of each subject. In addition, the exercises were generally similar to tasks that were familiar to the subjects (e.g., rising from a chair) and a part of everyday mobility. Three

classes were undertaken each day with 9–10 subjects in each class and three trainers (one physical therapist and two kinesiologists) per class.

Subjects were familiarized with the 16 point Borg Rating of Perceived Exertion (RPE) (6) and the rating scale was visible from all areas of the room. Subjects were asked throughout the exercise program to determine their RPE. The trainers encouraged subjects to work at a level between 11 and 13 (fairly light to somewhat hard) and to ensure that they did not exceed a level 15 (hard). Subjects took home a feedback sheet at the end of each class which asked subjects to indicate whether muscle soreness and general fatigue interfered with any of the subject's daily activities following the exercise session. They returned it the following session so that the trainers could ensure that subjects were not overly sore or fatigued from the previous session.

Statistical analyses

A repeated measures ANOVA was used to compare the outcome measures at the four assessment times (baseline one, baseline two, post-intervention one, post-intervention two) and was followed by Tukey's post-hoc test when a significant time effect was found (SPSS 9.0, SPSS Inc.). This ANOVA was performed for each of the outcome measures: 1) Berg Balance Test, 2) 12 Minute Walk Test distance, 3) self-paced gait speed, 4) fast-paced gait speed, 5) self-paced stair speed, 6) fast-paced stair speed, and 7) RNL Index. As the COPM was only undertaken at two time points, paired t-tests were undertaken to assess the change in the COPM Performance Score, and COPM Satisfaction Score. Correlational analyses were undertaken to relate the change in the outcome measures with the baseline values to determine whether the baseline level of function related to improvement. A significant level of $p < 0.05$ (two-tailed) was selected for all statistical tests.

RESULTS

Subject characteristics and participation

A total of 25 subjects completed the training program and post-intervention tests (see Table 1 for subject characteristics) with subjects attending a mean 94% of the classes. Five subjects completed the first pre-assessment, but did not undertake the training program for the following reasons: three did not feel that the program would be beneficial for them and two had changes to their schedule and left the country on holiday. One subject completed three weeks of the training program, and then underwent surgery and did not return. Comorbidities included hypertension (15 subjects), obesity with body mass index greater than 30 (five subjects), diabetes (three subjects), hyperlipidemia (five subjects), clinical depression (four subjects) and sedentary lifestyle (exercise < three times/week) (25 subjects).

Baseline measures

Given the lack of significant difference between the two baseline measures (see section below: Effect of test time on the outcome measures), the T2 measures are presented here to provide an indication of baseline values. There was a large range in motor function with baseline measures of self-paced gait speed, 12MWT, and Berg Balance Test ranging

between 0.28 to 1.14 m/s, 148 to 691 m, and 31 to 51 points, respectively. Mean self-paced gait speed was less than 50% of healthy older adult values (45) and the 12MWT distances were less than 60% of values reported in chronic respiratory subjects (31). On the other hand, baseline RNL scores were relatively high (all mean scores were above 80 out of a possible 100). For the COPM, subjects most frequently identified problems involving functional mobility (e.g., walking tolerance, transfer ability, stairs) and personal care (e.g., shaving, dressing).

Effect of test time on the outcome measures

There was a significant test time effect ($p < 0.05$) for the following six variables 1) Berg Balance Test, 2) 12MWT distance, 3) self-paced gait speed, 4) fast-paced gait speed, 5) self-paced stair speed, and 6) fast-paced stair speed (Table 2). Tukey's Post-hoc analyses on these six variables found no difference between T1 (baseline one) and T2 (baseline two) demonstrating that the baseline measures were stable over one month. For all six of these variables, there was a significant difference between T2 (baseline two) and T3 (post-intervention one), demonstrating a training effect for these variables. Lastly, there was no difference between T3 (post-intervention one) and T4 (post-intervention two) demonstrating a retention effect for these six measures. The RNL Index stayed within one point between T1 (baseline one) and T2 (baseline two) and then increased five points between T2 (baseline two) and T3 (post-intervention one), however, this increase was not significant. There was a significant intervention effect for the COPM for both the Performance and Satisfaction Score.

Change in outcome measures and relation to baseline measures

Those with the poorer balance demonstrated the greatest percent improvement with the Berg Balance Scale ($r = -0.72$, $p < 0.001$). In fact, those below the median Berg Score had a mean change of four points, while those above only changed one point. Gait and stair climbing improvement ranged from 5–15%. Significant correlations were found ($r = -0.4$ to -0.6 , $p < 0.05$) between the walking measures and percent improvement, suggesting that those with lower baseline function improved the most. Lastly, strong correlations were found ($r = -0.76$, $p < 0.001$) between the baseline RNL and the improvement in RNL, suggesting that those with poorer life satisfaction improved the most in this domain.

DISCUSSION

The program accommodated community-dwelling individuals with a wide range of function with gait speed as slow as 0.28 m/s and a Berg Score as low as 31. In addition, subjects with a number of comorbidities were able to tolerate the program.

Program Adherence

Adherence to the program was excellent and may have been facilitated by the collegiality which developed among participants and the tremendous encouragement and support they provided to one another. Others have reported similar observations regarding the social benefits of a group community exercise program in stroke (37,39).

There is some evidence which has shown that perceptions of excessive exertional demands or the lack of confidence in the ability to perform the exercise are barriers to sustained physical activity (27). One subject commented that he really enjoyed the first four weeks of the program, but that he did not enjoy the latter four weeks of the program as much due to the increasing exercise intensity. A moderate exercise intensity such as was followed in this study might help to promote life-long exercise adherence, as opposed to more challenging programs.

Subject-staff ratio

The trainers felt that an increase beyond the 3:1 client-staff ratio could only be safely undertaken if there was more focus on strengthening and less on the challenging agility and balance exercises which required close supervision. Alternatively, a reduction in the number of subjects with low motor function would maintain the safety of the program and reduce the need for so many staff. Four subjects who required close supervision had either the lowest Berg Balance Scores (31–33) and/or the slowest gait speed (0.27–0.28 m/s). Thus, one might consider each subject's balance or gait performance to distribute the number of subjects with low function across groups, or to increase the staff-client ratio for groups with lower function.

Physical outcome measures

In our intervention, the training (e.g., strengthening, balance) was undertaken within the context of everyday functional tasks. We believe that such an exercise program was not only meaningful to the subjects, but the task-specificity of the training contributed to the carry-over to those activities which are important for mobility. Despite the “chronic” nature of the participants' injury, improvements were found for all physical measures in this group of subjects. As some subjects were as much as 12 years post-stroke, this study demonstrates that improvements in balance and functional capacity can be acquired through practice well after the initial stroke episode. A limitation of the 12MWT outcome measure should be noted. The 12MWT distance reflects the ability to undertake everyday activities and may be a good indicator of functional capacity required for normal daily activities, however, it is not necessarily a measure of cardiovascular function (15,16). The 12MWT is influenced by cardiorespiratory and cardiovascular fitness, in addition to factors such as motivation, neuromuscular function, and peripheral muscle strength (16).

Importantly, the improvements in the physical outcome measures were retained at least one month following the cessation of the program. The greater percent improvement for individuals with lower function is an important observation as these individuals are at a higher risk for falls and cardiac disease. In addition, even small changes for these very impaired individuals have the potential to result in clinically significant effects. Accessible evidence-based community-based exercise programs are urgently needed to encourage persons to engage in regular physical activity post-stroke. Recently, World Health Organization issued a warning that sedentary lifestyle is one of the more serious yet insufficiently addressed public health problems of our time and attribute 2 million deaths per year to physical inactivity. Adherence to exercise programs has the potential to improve

activity tolerance, reduce the risk of falls and cardiac events, and maintain or improve functional mobility and physical independence.

A limitation of the study design was the absence of an independent control group. However, the baseline measures were found to be stable over a full one month period and the intervention produced a consistent response for six different physical function measures (i.e., no difference between the two baseline measures, a significant improvement from the intervention and a plateau following the intervention indicating retention of these abilities). The Berg and 12MWT appeared to have some learning or familiarization effect after the first test session, however, these baseline changes were not significant, and in addition, the changes from the intervention were up and above any changes observed during the two baseline measures.

Could the improvements in motor function be simply a result of time or functional recovery? Motor recovery typically shows the greatest improvements between 3 and 6 weeks post-injury and a clear plateau is reached by 90 days (13, 20). Our subjects were a minimum of one year post-stroke and were therefore at the “chronic” stage and one would expect little changes with standard rehabilitation efforts at this point in time. In fact, a post-hoc analyses of our data found no relationship between improvements in function and length of injury (e.g., correlation of Berg improvement and length of injury was $r=0.008$, $p=0.97$). Our study represents one of the few studies which has demonstrated the ability to improve balance function in chronic stroke. Only one other study in the literature has demonstrated balance improvements (43) while others found no change even with intensive treatments like aerobic treadmill training or muscle conditioning (14, 38). A number of reasons may attribute to the difficulties in improving balance function in a chronic stroke population: 1) previous interventions may have addressed specific structures that relate to balance (e.g., muscle strength), however, the interventions may not have sufficiently challenged balance in the context of the large variety of tasks and movements under which balance is required, 2) impaired balance is predominantly a result of the nature and severity of the neurological lesion and may not be improved to a large extent, and 3) there is a underlying decline in mobility with time given the older age of this group and perhaps even maintenance (but not necessarily improvement) in balance function is an accomplishment. In fact, Wade et al. (41) reported deterioration in mobility over a three month period in individuals with chronic stroke.

Psychosocial outcome measures

The RNL Index is a measure of satisfaction with physical and social performance, including coping skills and comfort in personal relationships (46). The absence of an intervention-effect found with this measure may be a consequence of the relatively high RNL scores found in this group, suggesting that several of these community-living individuals had adapted to their situation and were relatively satisfied. In fact, four subjects had complete satisfaction with their lives (score of 100) at the baseline assessment. In this subject group, the mean time since the onset of stroke was four years and it is reasonable to expect that some subjects have adapted psychologically and physically to their impairments. Similar results were reported by Bastien and her colleagues (1) among community-dwelling

individuals with stroke. A high level of emotional well-being was also recently noted by Hackett et al. (22) who reported that some individuals with chronic stroke appear to adjust psychologically to their illness despite significant and ongoing physical disability. On the other hand, the strong relationship between the baseline RNL Index and the improvements in the RNL Index suggests that exercise had the greatest effects on health-related quality of life for those individuals who commenced the program with low satisfaction of their physical, social and emotional lives.

In addition, the exercise intervention did have an impact upon perceptions of performance and satisfaction as measured by the COPM. The COPM is an individualized outcome measure that detects change in the performance of activities and satisfaction of that performance that are relevant and important to the person. It was not surprising that functional mobility was one of the most common identified problems as improved walking has been previously reported to be the most frequently stated goal by individuals with stroke (6). Thus, the noted improvements in gait performance may have been particularly important to these subjects.

The results of this study suggest that the effect of an exercise program which focuses upon and improves strength, endurance and balance is meaningful to the subjects and also has a demonstrable impact upon the performance and satisfaction of this performance relevant to daily living activities. This relationship between physical activity and improved health-related quality of life is in agreement with literature examining other chronic diseases (35). The effects on health-related quality of life measures (e.g., RNL, COPM) can be considered as important as the effects on physical function. There is a growing recognition that health-related quality of life can be an outcome in itself and this sentiment is reflected by the Healthy People 2010 Report (national health objectives for the United States) whose top priority now includes improving quality of life, in addition to increasing life expectancy (40). Recently, the World Health Organization also provided greater focus on “quality of life” with its revised International Classification of Functioning, Disability and Health (ICF) (44) which emphasizes how people live with their health conditions and the achievement of a productive, fulfilling life. Multiple dimensions exist for the term “health-related quality of life” (35) and the measures used in this study focused on the satisfaction of physical function, emotional lives and social lives and are representative of the “participation” dimension of the ICF (44).

The improvements found in this study for the health-related quality of life measures have important implications for potentially countering the high incidence of clinical depression documented in people with stroke (4, 10). In addition, a perception of improved well-being can only augment adherence to community-based exercise programs

Community-based programs for stroke survivors

This is an urgent need to define safe and effective community-based exercise programs to enhance mobility and fitness of individuals with chronic stroke who generally are older, less fit, and are prone to falls. Thus, we designed a group exercise program which could be easily implemented into the community as it did not require costly one-on-one training ratios, specialized settings and expensive equipment. The challenge was to achieve a level of

exercise intensity which would result in positive effects, yet ensure safety to avoid an exercise-related fall or cardiovascular event. Rimmer et al. (37) used a screening symptom-limited graded exercise test to obtain peak $\dot{V}O_2$ measures to grade the cardiovascular component of the exercise program. This screening stress test is advantageous in identifying those individuals who may have a negative response to exercise and can also determine an individualized exercise intensity which can be safely undertaken with the client. However, a screening stress test may also eliminate a large number of potential clients; the stress test is not an assessment that is readily available to the community and lower functioning candidates may be limited in part by peripheral factors in addition to central fatigue.

In this study, screening was undertaken using a modified Par-Q test, in addition to confirmation that the specified exclusion criteria were met. However, the lack of a symptom-limited exercise test prohibited a high intensity cardiovascular component. Instead, a moderately-high exercise intensity was undertaken and monitored with the use of ratings of perceived exertion. The results of this study showed that a short-term community-based exercise intervention can improve mobility, functional capacity and balance and retain these improvements. In addition, an exercise intervention can have a demonstrable impact upon the performance of activities and abilities that are considered meaningful to the participants and may in turn promote exercise adherence. Implementation of such community-based programs have potential for improving activity tolerance and reducing the risk of cardiac events and falls resulting in fractures, which are secondary complications which occur frequently in stroke.

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Figure 1.
Walking circuit

Table 1**Subject Characteristics (N=25)**

Variable	Mean	STD	Range
Gender (M/F)	19/6		
Hemiparetic Side (L/R)	13/12		
Type of Stroke (ischemic/hemorrhagic/unknown)	14/9/2		
AHASFC (I/II/III/IV)	14/8/2/1		
Mobility Aid (cane & brace/cane/brace/no aid)	7/5/2/11		
Chedoke McMaster Lower Extremity Score (/14)	8.72	2.23	5–12
Ashworth Scale (/5)	1.12	1.08	0–5
Age (years)	63.16	8.50	50–82
Time Since Stroke (years)	4.24	2.86	1–12
Mass (kg)	78.11	16.88	43–103
Height (cm)	166.86	11.96	141–185

Abbreviations: American Heart Association Stroke Function Classification (AHASFC)

Table 2

Outcome measures at each time

Time	T1	T2	T3	T4
Variable	Baseline 1	Baseline 2	Post-intervention 1	Post-intervention 2
1. Berg Balance Test/56 *	44.7 (6.0)	45.9 (5.3)	48.0 (5.3)	48.3 (4.3)
2. 12-min walk (m) *	425.4 (172.6)	442.1 (164.5)	465.0 (165.7)	470.3 (167.2)
Gait speed (m/s)				
3. Self pace *	0.65 (0.23)	0.70 (0.27)	0.79 (0.30)	0.76 (0.27)
4. Fast pace *	0.88 (0.36)	0.89 (0.36)	0.99 (0.38)	0.97 (0.37)
Stairs (steps/sec)				
5. Self pace *	0.71 (0.26)	0.72 (0.29)	0.83 (0.30)	0.81 (0.31)
6. Fast pace *	0.87 (0.30)	0.88 (0.33)	1.00 (0.36)	0.98 (0.35)
7. RNL Index ***	80.3 (15.2)	81.3 (12.6)	86.0 (12.0)	80.0 (16.6)
8. COPM Performance **	-	3.5 (1.5)	5.9 (1.7)	-
Satisfaction **	-	3.7 (1.9)	5.7 (1.8)	-

* Significant time effect, Tukey's post-hoc found difference between T2 and T3, but not difference between T1 and T2 or T3 and T4.

** Significant time effect, paired t-test found differences between T2 and T3

*** No significant time effect