Circuit Class Therapy Versus Individual Physiotherapy Sessions During Inpatient Stroke Rehabilitation: A Controlled Trial

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Objective: To compare the effectiveness of circuit class therapy and individual physiotherapy (PT) sessions in improving walking ability and functional balance for people recovering from stroke.

Design: Nonrandomized, single-blind controlled trial.

Setting: Medical rehabilitation ward of a rehabilitation hospital.

Participants: Sixty-eight persons receiving inpatient rehabilitation after a stroke.

Interventions: Subjects received group circuit class therapy or individual treatment sessions as the sole method of PT service delivery for the duration of their inpatient stay.

Main Outcome Measures: Five-meter walk test (5MWT), two-minute walk test (2MWT), and the Berg Balance Scale (BBS) measured 4 weeks after admission. Secondary outcome measures included the Iowa Level of Assistance Scale, Motor Assessment Scale upper-limb items, and patient satisfaction. Measures were taken on admission and 4 weeks later.

Results: Subjects in both groups showed significant improvements between admission and week 4 in all primary outcome measures. There were no significant between group differences in the primary outcome measures at week 4 (5MWT mean difference, .07m/s; 2MWT mean difference, 1.8m; BBS mean difference, 3.9 points). A significantly higher proportion of subjects in the circuit class therapy group were able to walk independently at discharge (P = .01) and were satisfied with the amount of therapy received (P = .007).

Conclusions: Circuit class therapy appeared as effective as individual PT sessions for this sample of subjects receiving inpatient rehabilitation poststroke. Favorable results for circuit classes in terms of increased walking independence and patient satisfaction suggest this model of service delivery warrants further investigation.

Key Words: Cerebrovascular accident; Physical therapy modalities; Rehabilitation.

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IT IS WELL ESTABLISHED that positive cortical reorganization poststroke in both the animal1-3 and human4,5 cortex is driven by activity and repetitive practice of new tasks. Furthermore, 2 recent meta-analyses6,7 have concluded that recovery of motor function in persons with stroke is best facilitated by providing intensive, task-specific therapy. However, observational studies have repeatedly shown that persons receiving inpatient rehabilitation poststroke spend large parts of the day inactive8-11 and appear to require the presence of a therapist to practice new skills.12 Providing task-specific therapy to groups of people with stroke in circuit classes has been proposed as a method of increasing the amount of time people spend actively engaged in task practice.12,13 Other benefits of group therapy include peer support and social interaction14 as well as potential cost-savings to the health care system by reducing staff to patient ratios.

Circuit class therapy can be defined as therapy: provided to more than 2 participants; involving a tailored intervention program, with a focus on practice of functional tasks received within a group setting; provided to participants with similar or different degrees of functional ability; and involving a staff to patient ratio no greater than 1:3.

Practically, this can involve participants physically moving between work stations set up in specific locations within each class, or participants performing a set of core activities adapted to suit individual needs within a group setting, but without the need to physically move between work stations. Optimally, the intervention is targeted at multiple levels, such as strength and balance and walking practice and range of movement. Participants’ progress is continuously monitored and activities are adapted as required. This definition is consistent with previous descriptions of circuit class therapy.6,13-15 This definition is also distinct from the concept of group therapy, which is defined as therapy involving more than 2 patients, usually with a similar degree of functional ability, undertaking the same exercises or activities at the same time under the direction of 1 therapist with little or no individual tailoring or progression of activities and usually targeting only 1 impairment (eg, balance or strength or aerobic fitness).

Circuit class therapy (consistent with the definition outlined above) has been shown to be effective for improving the mobility of people greater than 6 months poststroke10,16 and for improving mobility and upper-limb function for people receiving rehabilitation poststroke, when provided in addition to individual physiotherapy (PT) sessions.15 However, the effectiveness of circuit class therapy as an alternative sole method of PT service delivery for persons receiving inpatient rehabilitation poststroke has not been investigated to date. Therefore our primary objective was to test the hypothesis that circuit class therapy would result in greater improvements in mobility and
balance than individual PT sessions. Our secondary objective was to investigate between-group differences in level of walking independence achieved, upper-limb function, length of stay (LOS) in rehabilitation, and patient satisfaction with therapy.

METHODS

Study Design

We conducted a single-blind, nonrandomized controlled trial. We obtained ethics approval from the University of South Australia and Royal Adelaide Hospital Research Ethics Committees.

Participants

Persons received inpatient rehabilitation poststroke. Specific inclusion and exclusion criteria were as follows.

Inclusion criteria. Subjects who were diagnosed with a cerebrovascular accident resulting in unilateral motor deficits; had sufficient ability to participate in circuit class therapy (ie, ability to follow 3-part commands, sit unsupported and stand with 1 person assisting); and were able to give informed consent.

Exclusion criteria. Persons who had suffered a cerebellar lesion; had a history of any neurologic disorder (excluding previous stroke); or regularly used a walking aid (excluding single-point cane) or required assistance for activities of daily living prior to their stroke.

Withdrawal criterion. Subjects were withdrawn from the trial if they suffered any significant medical complication and/or were readmitted to an acute hospital for more than 1 week.

Recruitment

We approached all persons admitted to Hampstead Rehabilitation Centre, Adelaide, South Australia, for rehabilitation poststroke between March 2002 and October 2003 who met the inclusion and exclusion criteria within the first 2 days after admission, and invited them to participate in the study.

Group Allocation

Within 3 days of admission to rehabilitation, we assigned consenting subjects to their treatment group. To ensure a sufficient number of circuit class participants at any one time for circuit class therapy sessions, it was not feasible to randomly allocate individual subjects to treatment groups. Instead, we allocated subjects in blocks according to the date of admission to rehabilitation. Subject recruitment occurred between March 2002 and October 2003 in 4 alternating blocks of time. Because of this, we were not able to conceal assignment to groups from the allocator, or blind the subjects or treating therapists to group allocation.

Evaluations

We assessed subjects on all outcome measures at admission, week 4 of rehabilitation, discharge from rehabilitation, and 6 months poststroke. An examiner who was unaware of the design and aim of the study and was blinded to subjects’ group allocation completed all subject assessments. The examiner remained blinded to the study design and aims, and subjects’ group allocation, until after data collection ceased. We considered the 4-week assessment as the primary end point of interest, as it was the average LOS for stroke rehabilitation at Hampstead Rehabilitation Centre at the time of the trial.

Measurements

Our primary outcome measures were gait speed measured by the five-meter walk test (5MWT), functional walking capacity as measured by the two-minute walk test (2MWT), and functional balance as measured by the Berg Balance Scale (BBS). For the 5MWT the assessor asked subjects to walk at a comfortable pace along a corridor which was marked at 3, 8, and 10m from the start position, without verbal encouragement. The assessor used a stopwatch to record the time taken to walk the middle 5m of the walkway. The 2MWT was conducted along the same walkway with large orange cones placed 1 and 9m from the start position. The assessor asked subjects to walk up and down the walkway, walking around the cones at each end, continuously for 2 minutes, at a comfortable pace, taking rests if required. The assessor counted the number of completed laps and at the end of the 2 minutes (measured on a stop watch) the subject was asked to stop and stand still. The walkway was marked at 0.5-m intervals and the assessor recorded the distance walked to the nearest 0.5m. In both the 5MWT and 2MWT, the assessor walked behind the subject at all times to avoid influencing the speed at which they walked. The BBS was assessed according to the standard protocol using the same equipment (stool, chairs, plinth) for each assessment.

Our secondary outcome measures were upper-limb function as measured by the upper-limb subscale of the Motor Assessment Scale (MAS) for stroke, which consists of the 3 upper-limb items added together to create 1 summary score, the degree of physical assistance required to walk as measured by the Iowa Level of Assistance Scale (ILAS), LOS in rehabilitation, and patient satisfaction as measured by a stroke-specific satisfaction questionnaire (adapted from Pound et al). We measured LOS as the number of days between admission and discharge from Hampstead Rehabilitation Centre.

All of the outcome measures have been shown to have acceptable interrater reliability and construct validity, and were applied using standardized protocols. Intrarater reliability of the primary outcome measures was measured by the assessor re-scoring videotaped performances of the first 10 assessments 4 weeks later.

In addition, we obtained information regarding sociodemographic and stroke characteristics from the subjects’ medical records, with the level of stroke severity measured at admission to rehabilitation using the FIM instrument, administered by the treating multidisciplinary team.

Interventions

Subjects received the allocated type of PT for the duration of their inpatient stay and non-PT components of multidisciplinary rehabilitation were provided to both groups per usual practice. The broad aim of both individual and circuit class treatment sessions was to improve subjects’ mobility and upper-limb function to allow safe discharge to either their own home or appropriate supportive accommodation. The treating therapist recorded details regarding the content and duration of each therapy session. Subjects received their allocated PT intervention for the duration of their inpatient stay. Independent practice outside of individual therapy times was not usual practice at Hampstead Rehabilitation Centre at the time and therefore was not encouraged for either group during the trial.

We provided circuit class therapy to groups of up to 6 patients at any one time with a maximum of 1 physiotherapist and 1 PT assistant providing supervision in each class. If there were less than 5 participants in the class, only 1 physiotherapist provided supervision. The same physiotherapist (with 5 years
of experience in stroke rehabilitation) supervised all circuit classes, although several different PT assistants were involved. Circuit class participants attended two 90-minute treatment sessions a day, 5 days a week, and performed a set of core activities that addressed their key impairments and functional limitations. These core activities were: sit-to-stand practice; strengthening lower-limb extensor muscles in weight-bearing positions; postural control in standing; walking practice including negotiating obstacles, steps, ramps, stairs, and outdoor surfaces; reach and grasp; and fine manipulation of everyday household items in both unilateral and bilateral tasks. These core activities were individually adapted for each subject by the treating therapist and progressed as required, such that the level of difficulty, complexity, and dosage (number of repetitions) matched each individual’s ability. For example, practice of sit-to-stand ranged from starting with the subject perched on the edge of a high plinth with 1 therapist assisting, to independent practice using a low chair with no assistance while holding a glass of water. Appendix 1 includes a comprehensive list of exercises included in the class. We incorporated walking on a treadmill (without body-weight support) into the class for each subject as soon as they were able to walk overground with minimal assistance. We progressed treadmill training by increasing time (up to a maximum of 20 min per session) and speed. Group activities such as relay races were incorporated into the majority of classes. Although treating therapists provided some verbal feedback during circuit class therapy, the majority of feedback was provided by setting up each task such that it provided a concrete goal and intrinsic feedback regarding its correct completion.

Individual therapy sessions occurred under the direct and constant supervision of a physiotherapist or PT assistant, on a 1 therapist to 1 subject ratio, for up to 60 minutes a day, 5 days a week. Several different physiotherapists with a range of experience in stroke rehabilitation were involved in providing individual therapy. Individual therapy sessions were not based on any particular treatment philosophy and were tailored to the individual based on the physiotherapist’s assessment. Therapists often used manual guidance and verbal feedback for correct completion of tasks.

Sample Size
Prospective power calculations based on the ability to detect a between-group difference of 0.2 m/s in walking speed with 80% power (α = .05) indicated that a sample size of 37 subjects per group was required. We considered 0.2 m/s to be the minimum clinically important difference in walking speed, based on previous findings of an inherent measurement error of approximately 0.17 m/s with repeated measurements of walking speed.25 We used an estimated standard deviation (SD) of 0.3 m/s in the calculation, based on data from previous studies involving similar patient groups.26,27

Data Analysis
We analyzed differences between treatment groups at baseline using the independent t test, or Mann-Whitney U test if data were not normally distributed or were ordinal in nature. When all data were available, analysis was by intention-to-treat. However, ongoing collection of data was not possible for the majority of subjects withdrawn from the trial because they were either readmitted to an acute hospital or refused assessment.

We analyzed differences between groups over time on continuous outcome measures (ie, 5MWT, 2MWT, BBS) using a linear mixed-model analysis (with time and group as fixed effects and subjects as a random effect). We chose this method over the general multivariate model analysis of variance due to the considerable amount of missing data within the final data set. The linear mixed-model analysis allows all available data to be included by constructing estimated mean scores where data are missing, thereby minimizing bias resulting from an analysis restricted to complete cases.27 When significant group by time interactions were found, we performed a post hoc pairwise comparison of mean scores to examine when these differences occurred. The post hoc tests used the same data set as that used for the linear mixed-model analyses—that is, it involved imputed values for missing data. We calculated 95% confidence intervals (CIs) for mean differences to further examine both significant and nonsignificant findings. Although the BBS is strictly an ordinal scale, we treated the data as continuous, because the range in scores was large and the distribution of scores closely approached normality. We used independent t tests to analyze between-group differences for hospital LOS, duration of therapy, and content of therapy. We used the Mann-Whitney U test to analyze between-group differences in MAS upper-limb subscale scores, and the chi-square statistic to analyze between-group differences in ILAS scores and responses to the patient satisfaction questionnaire. Analyses of the MAS upper-limb subscale scores, ILAS, and patient satisfaction questionnaire were based on cross-sectional data, not change scores. We used the SPSS® for all analyses, with a significance level of α equal to .05.

RESULTS
We conducted the trial between March 2002 and December 2003. Seventy-eight subjects consented to participate and were allocated to groups. Figure 1 depicts the progression of subjects through the trial and the reasons for exclusion and withdrawal. Ten subjects withdrew before the week 4 assessment and a further 4 subjects withdrew between week 4 and discharge. Table 1 presents reasons for the 14 subjects who were withdrawn from the study. One subject withdrew from the circuit class therapy group after week 4 due to safety concerns. Although this subject received individual therapy for the remainder of her inpatient stay, we included her discharge and follow-up data in the circuit class therapy group for all analyses according to intention to treat principles. Only 43 (63.2%) subjects attended the follow-up assessment. Those subjects who did attend had a faster walking speed at discharge than those who did not attend (attendees, .81 ± .43 m/s; nonattendees, .59 ± .38 m/s; P = .04; t = −2.08, 95% CI, .01 – .46). There were no significant differences in discharge 2MWT scores and BBS data between those subjects who did and did not attend the follow-up assessment.

Intrarater reliability for the primary outcome measures was high, with intraclass correlation coefficient scores of 1.00, 1.00, and 0.96 for the 5MWT, 2MWT, and BBS scores, respectively.

Table 2 presents baseline characteristics of subjects included in data analyses. Data from the 5MWT and 2MWT were highly skewed at admission due to 21 (30.9%) subjects being unable to walk. There were no significant differences between treatment groups at baseline for any of the primary outcome measures or the admission FIM score. However, circuit class therapy subjects were significantly younger (individual therapy, 68.9 ± 12.3 y; circuit class therapy, 61.6 ± 11.8 y; P = .02).

Table 3 presents summary data for all outcome measures. The linear mixed-model analyses demonstrated a significant group by time interaction effect for each of the 3 primary outcome measures (5MWT: F = 2.88, P = .04; 2MWT: F = 6.82, P < .001; BBS scores: F = 2.79, P = .04) suggesting that the
treatment groups behaved differently over time. Post hoc pairwise comparisons of mean scores demonstrated that both groups showed significant improvement between admission and week 4 on the 5MWT (mean improvement: individual therapy, .16m/s; circuit class therapy, .17m/s), the 2MWT (mean improvement: individual therapy, 21.3m; circuit class therapy, 16.5m), and the BBS (mean improvement: individual therapy, 8.9 points; circuit class therapy, 8.5 points). Both groups continued to show significant improvement in all 3 measures between week 4 and discharge; however, only subjects receiving individual therapy showed significant improvement in the 5MWT and 2MWT between discharge and follow-up. There were no significant between-group differences at any time point, with the exception of the follow-up assessment at which subjects in the individual therapy group scored significantly higher on the 2MWT. Analyses were repeated with age as a covariate, which did not alter results.

There were no significant differences between groups on the MAS upper-limb subscale at any time point. There was a low frequency of scores on the ILAS for the majority of categories; therefore, data were collapsed into 2 categories (independent, assistance required/unsafe to attempt assessment) prior to analysis. At discharge a significantly higher proportion of subjects in the circuit class therapy group \( n=26 \) [92.9%] were able to walk independently compared with the individual therapy group \( n=23 \) [67.6%], \( \chi^2 \) test = 5.89, \( P = .01 \). There were no significant differences between groups in the responses to the patient satisfaction questionnaire at discharge or follow-up.
with 1 exception. At follow-up, significantly more subjects in the circuit class therapy group agreed or strongly agreed (n=21 [95.5%]) that they had received enough PT during their inpatient rehabilitation stay compared with the individual therapy group (n=11 [55.0%]; χ² test=12.27; P=.003) (see table 3).

We calculated LOS for all 64 subjects who completed the trial, including 2 subjects who refused to complete the discharge assessment. Discharge was delayed (due to waiting either for a bed in a residential care facility or for essential home modifications to be completed) for 8 subjects (5 in the individual therapy group, 3 in the circuit class therapy group). LOS for these subjects was calculated as the number of days between admission to rehabilitation and the date of the discharge assessment (this assessment occurred within 1 week of the multidisciplinary team deciding that the patient was ready for discharge). Although subjects in the circuit class therapy group had a shorter mean LOS (mean difference, 15.2d), this did not reach statistical significance (95% CI, −7.7 to −4.0). Significantly more individual therapy sessions included practice of transfers (including bed-to-chair, bed-to-toilet, and car transfers, but not including sit-to-stand practice, P<.001, t=4.37; 95% CI, 1.7−5.2) and exercises aimed at improving gait quality (P<.001, t=7.68; 95% CI, 6.3−11.1).

**DISCUSSION**

We found no clinically important or statistically significant differences between circuit class therapy and individual PT sessions for recovery of walking ability, functional balance, and upper-limb function among a sample of persons receiving inpatient rehabilitation poststroke. However, a significantly greater number of subjects in the circuit class therapy group were able to walk independently at discharge from rehabilitation and were satisfied with the amount of therapy received compared with subjects who received individual therapy. The sample included in our study can be considered representative of a larger population of persons receiving inpatient rehabilitation after stroke because it included a broad range of functional disability at baseline.

Despite the fact that subjects in the circuit class therapy group did not receive individual treatment sessions, there were few significant differences between the groups in terms of walking ability, functional balance, and upper-limb function, with subjects in both groups showing significant improvement over time. In addition, circuit class therapy was more effective than individual therapy in promoting independence in walking at discharge from rehabilitation in this sample of subjects. This may have been due to circuit class therapy subjects spending a significantly greater amount of time engaged in walking practice. Additionally, the structure of circuit class therapy was such that it encouraged greater participant autonomy, thereby encouraging problem solving and independence. Thus, it is possible that not only the increased amount of walking practice, but also the environment in which this practice occurred, had an impact on the increased level of walking independence.

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**Table 1: Reasons for Subject Attrition**

<table>
<thead>
<tr>
<th>Reason for Attrition</th>
<th>Individual Therapy</th>
<th>Circuit Class Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected low-limb fracture after fall on ward</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Suspected extension of stroke</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Withdrawal of informed consent</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lower-limb vascular surgery required</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Acute illness requiring readmission to an acute hospital (decreased respiratory function, severe urinary tract infection, acute bowel obstruction)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Discharged within 2 weeks</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Acute psychiatric illness requiring readmission to an acute hospital</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total number of subjects lost</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 2: Baseline Characteristics of the Study Sample**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Individual Therapy (n=37)</th>
<th>Circuit Class Therapy (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD (y)</td>
<td>68.9±12.3</td>
<td>61.6:11.8*</td>
</tr>
<tr>
<td>Mean FIM score ± SD (range, 18–126)</td>
<td>78.7±17.6</td>
<td>83.1:16.5</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>25/12</td>
<td>16/15</td>
</tr>
<tr>
<td>Side of stroke lesion (left/right)</td>
<td>15/22</td>
<td>11/20</td>
</tr>
<tr>
<td>Stroke type (infarct/hemorrhage)</td>
<td>34/3</td>
<td>24/7</td>
</tr>
<tr>
<td>Mean time between stroke and admission to rehabilitation ± SD (d)</td>
<td>24.4±12.4</td>
<td>29.7±15.5</td>
</tr>
</tbody>
</table>

*Statistically significant difference at P<.05.
within the circuit class therapy group. All known previous studies of circuit class therapy involved subjects who were already able to walk independently at baseline.14,16,38-40 Therefore, this study is the first to show that circuit class therapy is effective in promoting independent walking ability poststroke. The reasons for the significant improvement in gait speed and functional walking capacity between discharge and follow-up for the individual therapy group but not the circuit class therapy group are explained in Table 3. The table presents the summary of main outcome variables, including

### Table 3: Summary of Main Outcome Variables

<table>
<thead>
<tr>
<th>Outcome Variables</th>
<th>Individual Therapy</th>
<th>Circuit Class Therapy</th>
<th>Mean Difference Between Groups (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5MWT (m/s)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean ± SD (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>0.37±0.40 (37)</td>
<td>0.41±0.43 (31)</td>
<td>−0.04 (−0.25 to 0.17)</td>
</tr>
<tr>
<td>Week 4</td>
<td>0.53±0.43 (36)</td>
<td>0.58±0.46 (30)</td>
<td>−0.07 (−0.28 to 0.14)</td>
</tr>
<tr>
<td>Discharge</td>
<td>0.72±0.43 (34)</td>
<td>0.76±0.41 (28)</td>
<td>0.02 (−0.20 to 0.23)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>0.95±0.45 (20)</td>
<td>0.85±0.48 (22)</td>
<td>0.13 (−0.09 to 0.35)</td>
</tr>
<tr>
<td><strong>2MWT (m)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>36.8±40.3 (37)</td>
<td>41.1±44.1 (31)</td>
<td>−4.3 (−26.3 to 17.6)</td>
</tr>
<tr>
<td>Week 4</td>
<td>58.1±48.7 (36)</td>
<td>57.6±44.9 (30)</td>
<td>−1.8 (−23.8 to 20.2)</td>
</tr>
<tr>
<td>Discharge</td>
<td>74.3±46.5 (34)</td>
<td>76.1±43.0 (28)</td>
<td>3.1 (−18.9 to 25.2)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>103.0±47.6 (20)</td>
<td>82.1±48.3 (22)</td>
<td>23.1 (0.21 to 46.0)*</td>
</tr>
<tr>
<td><strong>BBS scores (range, 0–56)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>28.2±17.7 (37)</td>
<td>32.3±15.5 (31)</td>
<td>−4.1 (−10.5 to 2.3)</td>
</tr>
<tr>
<td>Week 4</td>
<td>37.1±16.4 (36)</td>
<td>40.8±12.9 (30)</td>
<td>−3.9 (−10.3 to 2.0)</td>
</tr>
<tr>
<td>Discharge</td>
<td>46.7±7.9 (34)</td>
<td>48.0±7.4 (28)</td>
<td>1.1 (−5.2 to 7.8)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>50.8±4.9 (20)</td>
<td>49.1±8.5 (22)</td>
<td>3.0 (−4.1 to 10.1)</td>
</tr>
<tr>
<td>Upper-limb MAS scores (range, 0–18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR) (n)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Admission</td>
<td>5.0 (0.8–12.0) (37)</td>
<td>10.0 (1.0–13.0) (31)</td>
<td>NA</td>
</tr>
<tr>
<td>Week 4</td>
<td>6.5 (1.0–13.0) (36)</td>
<td>12.0 (1.0–14.0) (30)</td>
<td>NA</td>
</tr>
<tr>
<td>Discharge</td>
<td>9.5 (4.8–14.0) (34)</td>
<td>12.0 (2.0–14.0) (28)</td>
<td>NA</td>
</tr>
<tr>
<td>Follow-up</td>
<td>13.0 (7.5–14.8) (20)</td>
<td>14.0 (2.0–16.0) (22)</td>
<td>NA</td>
</tr>
<tr>
<td>No. of subjects rated as independent on the ILAS</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>N (%) (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>7 (18.9) (37)</td>
<td>7 (22.6) (31)</td>
<td>NA</td>
</tr>
<tr>
<td>Week 4</td>
<td>14 (38.9) (36)</td>
<td>15 (50.0) (30)</td>
<td>NA</td>
</tr>
<tr>
<td>Discharge</td>
<td>23 (67.6) (34)</td>
<td>26 (92.0) (28)*</td>
<td>NA</td>
</tr>
<tr>
<td>Follow-up</td>
<td>17 (85.0) (20)</td>
<td>19 (61.3) (22)</td>
<td>NA</td>
</tr>
<tr>
<td>Responses to the question “I have had enough physiotherapy” at follow-up</td>
<td>n=21</td>
<td>n=22</td>
<td></td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>10 (50.0)</td>
<td>13 (59.1)</td>
<td>NA</td>
</tr>
<tr>
<td>Agree</td>
<td>1 (5.0)</td>
<td>8 (36.4)</td>
<td>NA</td>
</tr>
<tr>
<td>Disagree</td>
<td>7 (35.0)</td>
<td>1 (4.5)</td>
<td>NA</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>2 (10.0)</td>
<td>0 (0.0)</td>
<td>NA</td>
</tr>
<tr>
<td>LOS (d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD (n)</td>
<td>71.3±44.0 (36)</td>
<td>56.1±31.1 (28)</td>
<td>15.2 (−4.5 to 34.7)</td>
</tr>
</tbody>
</table>

Abbreviations: IQR, interquartile range; NA, not applicable.

*Statistically significant between-group difference at $P<.05$.

within the circuit class therapy group. All known previous studies of circuit class therapy involved subjects who were already able to walk independently at baseline.14,16,38-40 Therefore, this study is the first to show that circuit class therapy is effective in promoting independent walking ability poststroke. The reasons for the significant improvement in gait speed and functional walking capacity between discharge and follow-up for the individual therapy group but not the circuit class therapy group are explained in Table 3. The table presents the summary of main outcome variables, including

### Table 4: Summary of the Activities of Individual and Circuit Class Subjects Over 20 Treatment Sessions Showing Means and Between-Groups Differences

<table>
<thead>
<tr>
<th>Activities</th>
<th>Individual Therapy</th>
<th>Circuit Class Therapy</th>
<th>Mean Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill training</td>
<td>0±0</td>
<td>5.84±5.62</td>
<td>−5.8 (−7.7 to −4.0)*</td>
</tr>
<tr>
<td>Gait quality</td>
<td>9.14±6.49</td>
<td>0.42±2.16</td>
<td>8.7 (6.3 to 11.1)*</td>
</tr>
<tr>
<td>Gait practice</td>
<td>6.27±5.36</td>
<td>15.19±5.06</td>
<td>−8.9 (−11.5 to −6.4)*</td>
</tr>
<tr>
<td>Upper-limb functional activities</td>
<td>4.97±5.24</td>
<td>4.81±6.30</td>
<td>−0.17 (−2.7 to 3.0)</td>
</tr>
<tr>
<td>Sit to stand</td>
<td>5.70±5.62</td>
<td>15.06±6.60</td>
<td>−9.4 (−12.3 to −6.4)*</td>
</tr>
<tr>
<td>Transfer practice†</td>
<td>3.78±4.74</td>
<td>0.32±0.79</td>
<td>3.5 (1.7 to 5.2)*</td>
</tr>
</tbody>
</table>

*Statistically significant difference at $P<.05$.

†Includes bed-to-chair, bed-to-toilet, and car transfers, but not sit-to-stand.
group are unclear. Moreover, these results should be interpreted with caution because 36.8% of the sample did not attend the follow-up assessment and those who did attend were somewhat less disabled at discharge than the nonattendees.

A strength of our study design was that circuit class therapy comprised a set of core activities, individually adapted and progressed such that each subject was always challenged to his/her maximum ability. This allowed the circuit class therapy to be the sole model of PT service delivery, rather than a package of treatment delivered in addition to usual therapy. Thus, the current study was able to demonstrate the feasibility of circuit class therapy as an alternative sole model of PT service delivery for a representative sample of persons receiving inpatient rehabilitation poststroke.

The ability to provide a significantly greater amount of therapy time with a lower staff to patient ratio in our study suggests that circuit class therapy may also be a more cost-effective method of therapy delivery. In our study the total amount of therapist time required to provide circuit class therapy for 6 patients was a mean of 130 minutes a day, whereas the total amount of therapist time required to provide individual therapy sessions for 6 patients was 222 minutes a day (based on a mean duration of 37 minutes for individual sessions). This represents a difference of more than 90 minutes a day of therapist time. Additionally, circuit class therapy participants received a significantly greater amount of therapy a day. This additional therapy time may have resulted in a shorter hospital LOS, because although the difference in LOS in our study was not statistically significant, the confidence interval suggested a trend in favor of circuit class group subjects (mean difference, 15.2d; 95% CI, −4.5 to 34.7d). Coupled with similar findings by Blennerhassett and Dite15 of a large, but not statistically significant, reduction in LOS associated with mobility related to circuit class therapy, it is clear that future research into the cost-effectiveness of circuit class therapy as an alternative method of service provision is required.

There is increasing emphasis being placed on the importance of patient satisfaction within health care evaluation and evidence based medicine.41-44 Several studies41,43,44 have found that the majority of persons recovering from stroke were not satisfied with the medical and rehabilitative care they received. Similarly, in our study 45% of subjects receiving individual therapy were not satisfied with the amount of therapy they received. Our finding that 95.5% of subjects receiving circuit class therapy were satisfied with the amount of PT they received is of particular clinical relevance, although perhaps not surprising, considering the increased amount of therapy time they received. However, this finding must be interpreted with caution in view of the large drop-out rate between discharge and follow-up. Nevertheless, patient satisfaction data collected at follow-up may be a more accurate reflection than that measured during inpatient rehabilitation, given that patients are often reluctant to express dissatisfaction with hospital services,45 and may therefore be more honest in reporting levels of satisfaction when they are no longer receiving hospital services.46

Study Limitations

The heterogeneous nature of the sample was a limitation of our study. Further research with a larger, more homogeneous sample of subjects with moderate disability may yield more definitive results, as it is well established that persons with stroke resulting in moderate disability demonstrate greater improvement in functional abilities during rehabilitation, compared with those with mild or severe impairment.47 Although the nonrandom allocation of subjects to groups in our study had the potential to bias the results, age was the only significant difference between the treatment groups at baseline, and the use of age as a covariant in the analyses did not alter the results. Although an additional limitation was the rate of subject attrition, the reasons for withdrawal from the study (see table 1) appeared to be unrelated to the type of therapy provided. Although 3 subjects suffered falls necessitating withdrawal from the study, all occurred outside of therapy sessions, making it highly improbable that the type of PT the subjects received was responsible. Additionally, although there were 2 cases of suspected extension of stroke, both occurring in the circuit class therapy group, neither was confirmed by radiologic examination. Some studies in the rat model have suggested that early, intensive therapy within the first week after stroke may increase the risk of stroke symptoms worsening.48 However, there have been no published reports of stroke extension or worsening stroke symptoms associated with increased intensity of therapy provided to persons more than a week after stroke. Nevertheless, it would be pertinent for future studies of circuit class therapy to include assessment of the incidence and severity of infarct extension. A further limitation of our study design was that the discharge assessment did not occur at a standardized time. However, the inclusion of these data made it possible to compare functional ability at discharge between treatment groups. These limitations of study design highlight the difficulties inherent in clinical research, in particular finding a balance between ideal study design, the practicalities of clinical research, and the applicability of the findings to a clinical setting.

Future research into the effectiveness of circuit class therapy is clearly warranted. Preferably, such research should involve a more homogeneous study sample, random allocation to treatment groups, and standardized assessment times. Although such studies would require significant financial support, the potential for circuit class therapy to be a more cost-effective method of service delivery and to reduce hospital LOS justifies this support.

CONCLUSIONS

Subjects receiving either circuit class therapy or individual therapy demonstrated a similar degree of recovery on objective measures of mobility and upper-limb function for person receiving inpatient rehabilitation after stroke. However, circuit class therapy was associated with a significantly greater degree of independence in walking at discharge from rehabilitation and significantly higher patient satisfaction with the amount of therapy received. Furthermore, the study demonstrated the feasibility and safety of circuit class therapy as an alternative sole model of PT service delivery for persons receiving inpatient rehabilitation after stroke.

Acknowledgments: We thank the staff of the Royal Adelaide Hospital Physiotherapy Department and Medical Rehabilitation Unit at Hampstead Rehabilitation Centre, in particular Julie McGuiness, for their support and assistance in conducting the trial.

APPENDIX 1: LIST OF EXERCISES INCLUDED IN CIRCUIT CLASS THERAPY

Lower-limb exercises

- Forward and lateral step raises. (Subject placed affected leg on a step placed in front of or to the side and raised him/herself onto step.)
- Eccentric quads over edge of step. (Subject stood on a step and lowered unaffected leg to touch the ground. To progress exercise, subjects touched a foam cup placed on
APPENDIX 1: LIST OF EXERCISES INCLUDED IN CIRCUIT CLASS THERAPY (cont’d)

**Exercises to improve postural control in standing**
- Reaching to touch marks or trace a spiral shape on a whiteboard. Different stance positions were used including feet together and tandem stance.
- Stepping grid. Subjects stood with feet in marked areas, then tapped 1 foot out to touch marks on floor, repeating with the other foot.
- Reaching to pick up objects from low surfaces or the floor. This exercise was also performed in pairs with subjects passing objects to each other.
- Alternatively tapping toes onto step in front. To progress the exercise, subjects had to tap a foam cup placed on the step without deforming it.
- Throwing and catching balls in pairs or groups.
- Practicing standing on 1 leg.
- Walking with a heel-toe gait or “braiding” (ie, walking sideways with the trailing leg alternating between crossing in front of, or behind the leading leg with each step).

**Exercises for the upper limb and hand**
- Prolonged shoulder positioning in either forward flexion or abduction. Where elbow contracture or stiffness was an issue, a circumferential foam splint was used to hold the elbow in maximal extension.
- Active shoulder girdle movement with the arm supported on a high surface.
- Reaching to grasp and move various size objects on and off of “shelves.”
- Taking lids on and off jars.
- Pegging washing onto a line.
- Throwing and catching balls in pairs or groups.

**Exercises to improve postural control in standing**
- Sit-to-stand and walking exercises
- Sit-to-stand from various heights including from an adjustable plinth, chairs with and without arms, and stools. To progress the exercise, subjects placed their unaffected leg on a small step.
- Stepping onto and off a step.
- Walking indoors, forward, backward, and sideways.
- Walking outdoors.
- Walking on the treadmill.
- Walking up and down stairs.
- Walking around obstacle courses including stepping over and around objects, up and down steps, over soft surfaces, and picking up objects from the floor. Subjects also negotiated obstacle courses while carrying a tray of objects (for dual-task performance).
- Praxic reaching exercises
  - Reaching to touch marks or trace a spiral shape on a whiteboard. Different stance positions were used including feet together and tandem stance.
  - Stepping grid. Subjects stood with feet in marked areas, then tapped 1 foot out to touch marks on floor, repeating with the other foot.
  - Reaching to pick up objects from low surfaces or the floor. This exercise was also performed in pairs with subjects passing objects to each other.
  - Alternatively tapping toes onto step in front. To progress the exercise, subjects had to tap a foam cup placed on the step without deforming it.
  - Throwing and catching balls in pairs or groups.
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- Active shoulder girdle movement with the arm supported on a high surface.
- Reaching to grasp and move various size objects on and off of “shelves.”
- Taking lids on and off jars.
- Pegging washing onto a line.
- Folding washing.

References
37. Little R, Raghunathan T. On summary measures analysis of the linear mixed effects model for repeated measures when data are not missing completely at random. Stats Med 1999;18:2463-78.

Supplier
a. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.