A Treadmill and Overground Walking Program Improves Walking in Persons Residing in the Community After Stroke: A Placebo-Controlled, Randomized Trial

Louise Ada, PhD, Catherine M. Dean, PhD, Jillian M. Hall, GradDipPhtyAppSc, Julie Bampton, MSc, Sarah Crompton, MAppSc

ABSTRACT. Ada L, Dean CM, Hall JM, Bampton J, Crompton S. A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial. Arch Phys Med Rehabil 2003;84:1486-91.

Objective: To evaluate the effectiveness of a treadmill and overground walking program in reducing the disability and handicap associated with poor walking performance after stroke.

Design: Randomized, placebo-controlled clinical trial with a 3-month follow-up.

Setting: General community.

Participants: A volunteer sample of 29 ambulatory individuals (less 2 dropouts) who were living in the community after having suffered a stroke more than 6 months previously.

Interventions: The experimental group participated in a 30-minute treadmill and overground walking program, 3 times a week for 4 weeks. The control group received a placebo consisting of a low-intensity, home exercise program and regular telephone contact.

Main Outcome Measures: Walking speed (over 10m), walking capacity (distance over 6min), and handicap (stroke-adapted 30-item version of the Sickness Impact Profile) measured by a blinded assessor.

Results: The 4-week treadmill and overground walking program significantly increased walking speed ($P=.02$) and walking capacity ($P<.001$), but did not decrease handicap ($P=.85$) compared with the placebo program. These gains were largely maintained 3 months after the cessation of training ($P\leq.05$).

Conclusions: The treadmill and overground walking program was effective in improving walking in persons residing in the community after stroke. This suggests that the routine provision of accessible, long-term, community-based walking programs would be beneficial in reducing disability after stroke.

Key Words: Exercise; Hemiplegia; Physical therapy techniques; Randomized controlled trials; Rehabilitation; Treatment outcome; Walking.

ON DISCHARGE FROM rehabilitation, 60% to 80% of stroke patients can walk independently.[1,2] However, they walk at speeds of .38 to .80m/s,[3-7] which is insufficient to function effectively in the community. Our study was designed to evaluate the effectiveness of a training program involving both treadmill and overground walking as a means of reducing the disability (ie, limitations to activity[8]) and handicap (ie, participation in society[8]) associated with poor walking performance in persons residing in the community after stroke.

Although physical therapy for patients with mobility problems more than 1 year after stroke has been shown to be effective, the improvements gained are not maintained after cessation of treatment.[6,9] Treadmill walking may be a useful intervention to improve both the speed and capacity of walking in such patients. In uncontrolled trials of chronic stroke patients, treadmill walking has been associated with increases in strength,[10,11] decreases in energy expenditure,[12,13] as well as increases in walking speed and quality.[14]

There is evidence to suggest that the content of a treadmill walking program is important in determining effectiveness. For example, Pohl et al[7] have shown the importance of manipulating the speed of the treadmill to achieve increases in overground walking speed. However, it has been shown that stroke patients generally achieve higher walking velocities by increasing their cadence rather than step length compared with normal.[15] We propose that treadmill walking be viewed as a form of "forced use" that may be used to improve the quality of walking as well as the quantity. The motion of the treadmill enforces the appropriate timing between the lower limbs and ensures that the hips are extended during stance phase, both of which are critical biomechanical components of walking.[16,17]

A randomized placebo-controlled clinical trial of a treadmill and overground walking program was carried out with ambulant stroke patients who were residing in the community. The walking program was structured to improve speed by increasing step length, capacity by increasing workload, and automaticity by introducing dual tasks. Treadmill walking was used to force an increase in step length, speed, and distance while overground walking followed treadmill walking to reinforce the pattern of walking achieved on the treadmill. This program was compared with a placebo because these people would not normally be receiving any structured therapy.

Furthermore, we were interested in whether any gains could be maintained. The research questions were: (1) In stroke patients able to walk independently but slowly, does 4 weeks of treadmill and overground walking increase speed and capacity of walking, improve quality of walking, and decrease handicap? and (2) In stroke patients able to walk independently but slowly, are gains after 4 weeks of treadmill and overground walking maintained 3 months after the cessation of training?

From the School of Physiotherapy, Faculty of Health Sciences, University of Sydney, Sydney (Ada, Dean, Hall, Bampton); and Physiotherapy Department, Prince Henry Hospital and Prince of Wales Hospital, South Eastern Area Health Service, Sydney, NSW (Crompton), Australia.

Supported by the National Stroke Foundation of Australia.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) is/are associated.

Correspondence to Louise Ada, PhD, Sch of Physiotherapy, University of Sydney, PO Box 170, Lidcombe NSW 1825, Australia, e-mail: *L.Ada@fhs.usyd.edu.au*. Reprints are not available.

0003-9993/03/8410-7889$30.00/0

doi:10.1053/S0003-9993(03)00349-6

Table 1: Subject Characteristics

	Age (y)		Height (m)		Weight (kg)		Time Since Stroke (mo)		Initial Walking Speed (m/s)	
	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con
Mean	66	66	1.68	1.69	79	73	28	26	.62	.53
SD	11	11	0.07	0.06	12	12	17	20	.24	.30
Range	50–83	51–85	1.54–1.84	1.57–1.80	54–106	50–87	7–60	9–72	.24–1.1	.06–1.0

Abbreviations: Con, controls; Exp, experimental; SD, standard deviation.

METHODS

Participants

Subjects were recruited via advertisements in local newspapers and clubs from individuals who were living in the community and had completed rehabilitation. Subjects were included if they had had their first stroke between 6 months and 5 years previously, presented with hemiparesis, were between 50 and 85 years of age, and were walking 10m independently with a speed of less than 1.2m/s. Subjects were excluded if they had cardiovascular problems such that their medical practitioner precluded them from participating in a training program, or had severe cognitive deficits such that they could not follow instructions. The study was approved by the relevant ethics committee and subjects were required to gain clearance from their local doctor before participating in this study.

Subjects were recruited in 2 cohorts, 4 months apart. Subjects in each cohort were ranked in descending order according to walking speed and organized into consecutive pairs. Subjects in the 14 pairs and the last subject were randomly allocated by coin toss to 1 of 2 groups—the experimental or the control group—by an investigator independent of recruitment and measurement. In total, 29 subjects agreed to participate in the study and gave informed consent. There were 2 dropouts, 1 from each group; the subject from the control group moved 600km away and the subject from the experimental group fell at home and fractured his hip. Therefore, 27 subjects completed the study—13 experimental (9 men, 4 women) and 14 control (10 men, 4 women) subjects. The experimental group consisted of 8 subjects with right hemiparesis and 5 with left hemiparesis, whereas the control group had 6 right and 8 left. Age, height, weight, time since stroke, and initial walking speed were similar between the groups and these characteristics are summarized in table 1.

Intervention

Training for the experimental group was carried out 3 times a week for 4 weeks. The training sessions were comprised of 30 minutes of walking, which actually took about 45 minutes to accomplish. Each session consisted of both treadmill and overground walking, with the proportion of treadmill walking decreasing by 10% each week from 80% in week 1 to 50% in week 4. Subjects received individual training from a physical therapist; however, there was some opportunity for social interaction because 2 subjects were trained concurrently. The program was carried out in a community setting and transport was provided if necessary.

The treadmill walking component was structured to increase step length, speed, balance, fitness, and automaticity. To increase step length, the treadmill was run at a comfortable speed and subjects were instructed either to "walk as slowly as possible" or to "take as few steps as possible" or to "keep the stance foot on the treadmill for as long as possible" or to "keep the swinging foot in the air for as long as possible." In addition, marching-type steps were included to encourage hip and knee flexion during swing phase to improve toe clearance. When a normal step length was observed, the speed of the treadmill was increased (until step length was compromised). When maximum speed was achieved, balance was challenged by reducing the degree of hand support and fitness encouraged by increasing the incline of the treadmill thereby increasing workload. Finally, automatically was promoted by presenting the subjects with a concurrent cognitive task. The cognitive task consisted of matching the word "red" with the response "yes" or the word "blue" with the response "no."[18] During treadmill walking, attention was also focused on alignment to help subjects to keep their trunk vertical.

The overground walking component aimed to reinforce improvements in walking pattern and speed achieved on the treadmill. It was defined as whole-task practice involving propulsion forward, backward, or sideways, or up and down stairs; that is, there were no isolated exercises or part practice of walking. To reinforce the increased step length, visual cues were supplied in the form of nonslip footprints that were laid at intervals normal for that subject's height. When step length approximated normal, subjects were encouraged to walk faster and were timed for feedback. Step width was reduced and balance challenged by forcing subjects to walk within 1 floor tile or walk along a line forward, sideways, and backward. Workload was increased by introducing stairs and slopes to overground walking practice and automaticity was promoted by the introduction of dual tasks. Subjects walked continuously around an outdoor circuit—which included curbs, slopes, stairs, and rough terrain—while conversing with the trainer. Overground walking also focused on walking alignment by encouraging an increase in hip extension and trunk verticality. Subjects walked sideways with their heels and shoulders in contact with a wall to encourage hip extension and trunk verticality.

The control group was given a home exercise program to carry out 3 times a week for 4 weeks. The program consisted of exercises to lengthen and strengthen lower-limb muscles as well as to train balance and coordination. However, although the exercises were individualized, they were not prescribed in sufficient number or intensity to achieve a training effect because the aim was to provide a credible sham program to control for the effect of placebo. Subjects were also encouraged to go for a walk every day. Subjects were telephoned once a week, and the exercises were progressed in number and/or type depending on progress during the previous week.

Outcome Measures

The main measures of disability were walking speed, measured over 10m, and walking capacity where the distance covered in 6 minutes was recorded.[19] Handicap was measured by using the stroke-adapted 30-item version of the Sickness

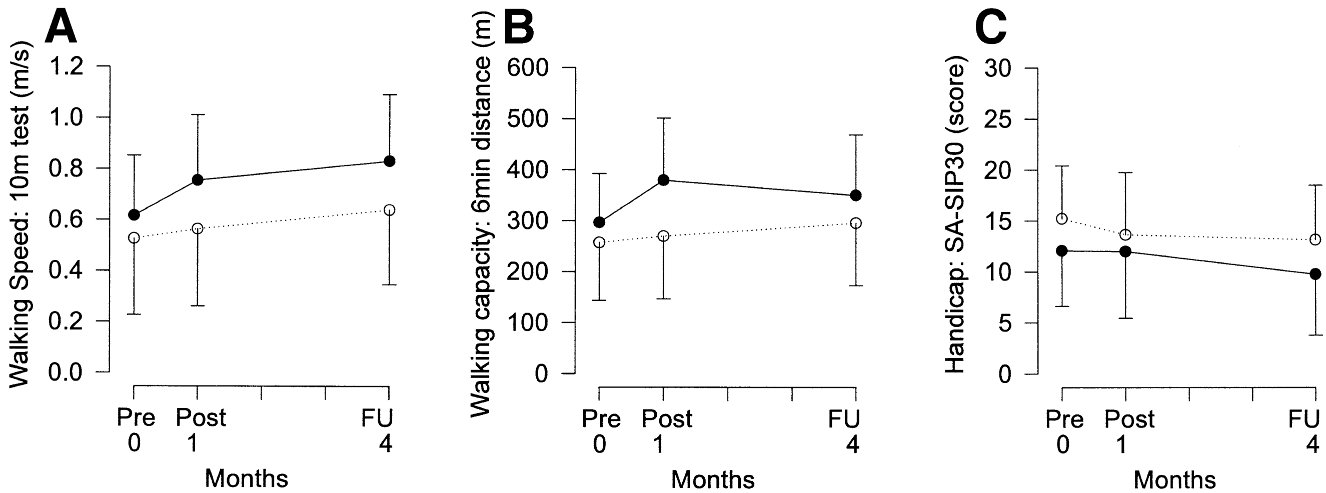

Fig 1. Means and SDs for the experimental group (●) and control group (○) at pretest (Pre), 1 month later at posttest, (Post), and 3 months later at follow-up (FU) for (A) barefoot walking speed over 10m, (B) distance covered in 6 minutes, and (3) handicap measured on the SA-SIP30.

Impact Profile[20] (SA-SIP30). In addition, subjects' quality of walking was assessed by measuring step length of both the affected and unaffected leg, cadence, and step width over 10m. For the 10-m walk, pens were attached to subjects heels so that marks of heel contact were recorded. Step length and step width were quantified by averaging the responses over the 10m, that is, at least 15 steps. Speed for the 10m and the duration of the 6-minute walk were measured by using a stopwatch. Measurements were taken before and after the 4-week program as well as at follow-up 3 months after the cessation of intervention. Measurement and training occurred on separate days to eliminate possible short-term effects of the training programs. The person collecting outcome measures was blinded to group allocation.

Statistical Analysis

Data collection yielded 2 variables that reflect the level of disability: walking speed over 10m and walking capacity over 6 minutes; 1 variable that reflects the level of handicap: score from the SA-SIP30; and 4 variables that reflect the quality of walking: affected and intact step length, step width, and cadence, repeated at 0 months (pretest), 1 month (posttest), and 4 months (3-mo follow-up). There were 2 factors: group and time, with 3 repeated measures on the time factor. Therefore, 2-way analyses of variance with repeated measures were used to determine whether there was an effect of the walking program on disability, handicap, and the quality of walking, immediately after intervention (ie, between pre- and posttest) and 3 months after the cessation of training (ie, between pretest and follow-up). Descriptions of the groups are presented as mean and standard deviation (SD) and effect sizes and 95% confidence interval (CI) are reported.

RESULTS

Disability and Handicap

The results are presented in figure 1 and table 2. By the posttest, walking speed had increased significantly more in the experimental group than in the control group ($F_{1,23}=6.53$, $P=.02$). By follow-up, walking speed remained significantly increased in the experimental group than in the control group ($F_{1,24}=6.74$, $P=.02$).

By the posttest, walking capacity had increased significantly more in the experimental group than in the control group ($F_{1,23}=18.19$, $P<.001$). By follow-up, walking capacity had decreased in the experimental group but still remained significantly increased compared with the control group ($F_{1,24}=4.10$, $P=.05$).

By the posttest, handicap had decreased slightly in both groups, but there was no significant difference between the

Table 2: Group Mean and SDs of All Outcome Measures and Change Scores

	Pretest (n=27)		Posttest (n=25)*		Posttest-Pretest (n=25)*		Follow-Up (n=26)†		Follow-Up − Pretest (n=26)†	
	Exp (n=13)	Con (n=14)	Exp (n=11)	Con (n=14)	Exp (n=11)	Con (n=14)	Exp (n=13)	Con (n=13)	Exp (n=13)	Con (n=13)
Walking speed 10m m/s	.62±.24	.53±.30	.75±.26	.56±.30	.18±.19	.04±.07	.83±.26	.64±.29	.21±.17	.08±.07
Walking distance 6min (m)	296±96	257±113	379±122	269±123	99±70	13±27	350±119	295±122	53±39	23±39
SA-SIP30 (score/30)	12.1±5.5	15.2±5.2	12.0±6.5	13.6±6.1	−1.3±4.3	−1.6±3.7	9.8±6.0	13.2±5.4	−2.3±2.7	−1.8±3.2
Step length affected (m)	.42±.11	.38±.14	.51±.12	.39±.13	.10±.08	.01±.04	.51±.10	.41±.11	.09±.06	.02±.03
Step length intact (m)	.39±.14	.33±.17	.47±.14	.35±.16	.10±.09	.02±.03	.48±.14	.38±.16	.09±.08	.03±.04
Step width (m)	.12±.04	.15±.06	.13±.04	.15±.06	.01±.03	.00±.02	.12±.04	.15±.06	.00±.02	.00±.03
Cadence (steps/min)	89±14	80±23	89±14	86±23	2±16	6±9	99±16	93±21	10±12	10±11

*Two subjects, both from the experimental group, could not be measured at posttest, both for medical reasons.
†One subjects, from the control group, could not be measured at follow-up, because she had moved away.

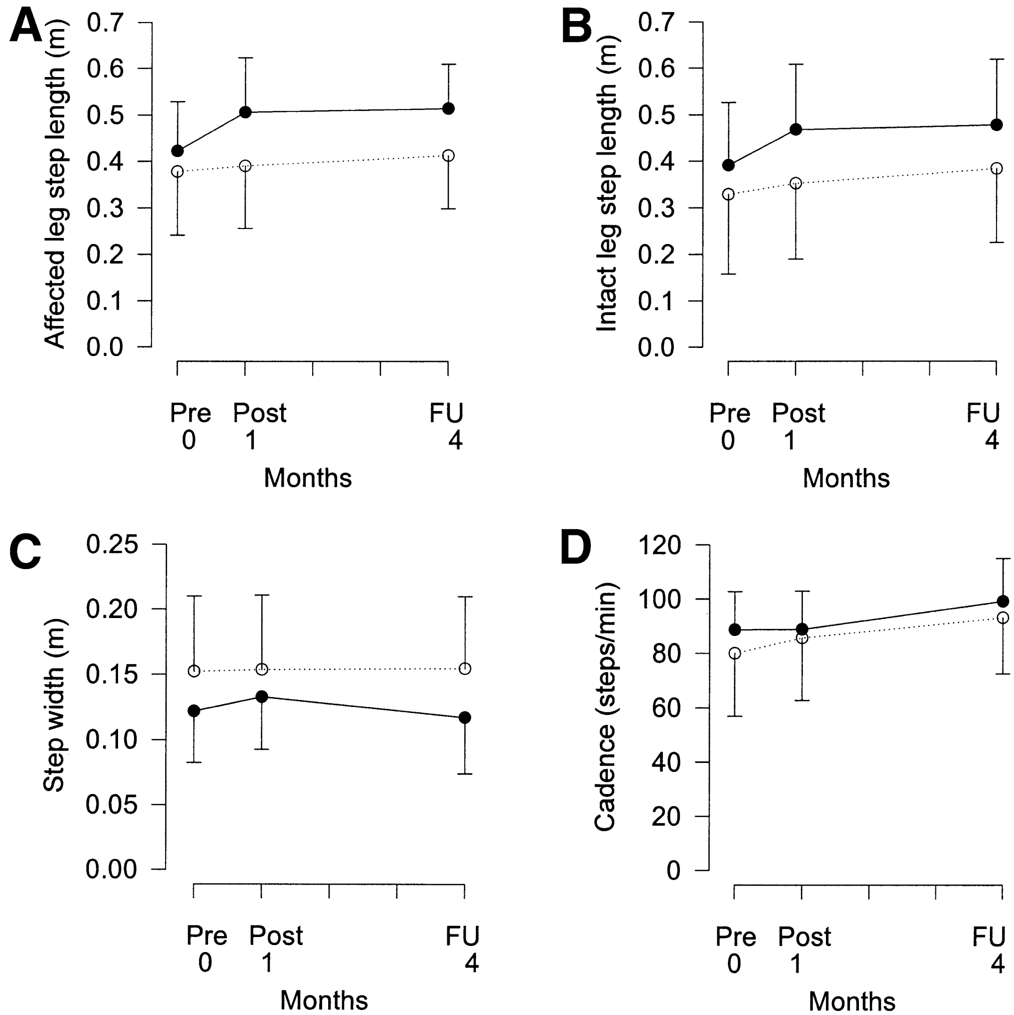

Fig 2. Means and SDs for the experimental group (●) and control group (○) at pretest, 1 month later at posttest, and 3 months later at follow-up for (A) step length of the affected leg, (B) step length of the intact leg, (C) step width, and (D) cadence.

groups (P=.85). After the cessation of training, a slight decrease occurred in the experimental group, but, by follow-up, there was still no significant difference between the groups (P=.69).

Quality of Walking

The results of the quality of walking measures are presented in figure 2 and table 2. By the posttest, step length for both the affected leg ($F_{1,23}$=12.5, $P<.01$) and the intact leg ($F_{1,23}$=9.7, $P<.01$) had increased significantly more in the experimental group than in the control group. By follow-up, step length remained significantly increased in the experimental group than in the control group for the affected leg ($F_{1,24}$=16.9, $P<.001$) and the intact leg ($F_{1,24}$=5.1, P=.03).

By the posttest, step width had remained constant in both groups and there was no significant difference between the groups (P=.35). By follow-up, there was still no significant difference between the groups (P=.60).

By the posttest, cadence had increased only in the control group but not enough to make a significant difference between the groups (P=.43). Between the posttest and follow-up measures, cadence increased in the experimental group so that by follow-up, the groups had both increased the same amount overall (P=.87).

Compliance With Training

The treadmill and overground walking program was held 3 times a week for 4 weeks. On average, subjects attended 11 of the 12 sessions. In week 1, the mean treadmill speed was 0.7m/s at the beginning of the session and 0.9m/s by the end of the session. In week 4, the session started with the treadmill speed at 1.0m/s and rose to 1.1m/s by the end. On average, the subjects walked 1.3km in 24 minutes in the first week and 1.1km in 15 minutes in the fourth week. By using the 10-point Borg Ratings of Perceived Exertion Scale,[21] subjects rated their perceived exertion as "strong" (ie, score=5) at the beginning and "very strong" (ie, score=7) at the end of the program.

Exercises for the control group were prescribed individually to be carried out at home 3 times a week for 4 weeks. Subjects were required to keep logs of their exercise routine. Logs had to be returned independently of the measurement sessions to keep the measurer blinded to group allocation and therefore were returned by only 8 of the 14 subjects. Two subjects had lost their logs and 1 subject was lost to follow-up. Of those returned, the exercises were carried out for an average of 11 of the 12 sessions. This level of compliance to a low-intensity, home exercise program suggests that it was a credible sham program.

DISCUSSION

This randomized placebo-controlled clinical trial showed that a 4-week treadmill and overground walking program increased walking speed, walking capacity, and step length in a group of subjects who were, on average, 2 years poststroke (initial walking speed=.56m/s; range, .06–1.1m/s). Furthermore, these gains were largely maintained 3 months after the cessation of training.

After 4 weeks of walking training, the experimental group had increased their walking speed by .14m/s (95% CI, .03–.25) more than the control group. Importantly, 3 months later, this effect was still .13m/s (95% CI, .02–.24). This is encouraging given that there were only 12 training sessions. Only 4 of the experimental group achieved speeds of over 1m/s, suggesting that more training would have been beneficial.

Furthermore, this increase in speed was achieved largely by an increase in step length rather than cadence. Walking velocity is a combination of the distance walked and how many steps are taken. This relationship is described in the equation:

$$\text{Speed} = \frac{\text{stride length} \times \text{cadence}}{120}$$

Wagenaar and Beek[15] have shown that, compared with normal, stroke patients increased walking speed by increasing cadence. In fact, an increase in cadence is how the control group achieved its small increase in speed. The experimental group, on the other hand, increased its speed by increasing its step length as a result of the focus on step length in both the treadmill and overground components of the walking program. Furthermore, the increases in step length were not solely the result of an increase in step length of the affected leg because step length was matched by increases in step length of the intact leg, probably as a result of better push off by the affected leg. After the 4 weeks of walking training, the experimental group had increased its affected step length by .09m (95% CI, .04–.14) and its intact step length by .08m (95% CI, .03–.13) more than the control group. This 21% increase represents the attainment of 90% of normal step length, which is .55m for this group.[22] Three months later, the experimental group had maintained its affected and intact step lengths, but now was increasing its speed by increasing cadence. Step width did not improve, suggesting that there was insufficient focus on balance in training. In the future, decrease in step width could be manipulated by painting lines on the treadmill belt within which subjects must walk.

After the 4 weeks of walking training, the experimental group had increased its walking capacity by 86m (95% CI, 44–128) more than the control group. This resulted in 55% of the experimental group achieving over 80% of its predicted 6-minute distance based on each subject's gender, age, height, and weight[23] compared with 7% of the control group. However, 3 months later, this effect was reduced to 30m (95% CI, 0–60). This suggests that there was a fitness component to the 4-week walking program that disappeared when training ceased. Macko et al[12] have suggested that maintenance exercise is necessary to sustain the benefits in cardiovascular fitness achieved after 3 months in chronic stroke. Although 8 subjects were exercising regularly before the study, only 1 subject had changed exercise behavior to include regular exercise after the study, which suggests that strategies to encourage routine exercise would have been a beneficial part of the program.

There was no effect of the training program on handicap (0.5/30 points; 95% CI, −3 to 2). Handicap was assessed by using the SA-SIP30, which includes multiple domains of life and is a self-rating scale. Because subjects were on average 2 years poststroke and living in the community, the 2-point reduction in handicap reported by both groups suggests that subjects felt empowered by taking part in the research study. The high levels of compliance with the programs for both groups supports this claim. In a follow-up survey, when asked whether walking was better, the same, or worse than before the program, 83% of the experimental group rated it as better, compared with 70% of the control group. When asked whether they went out more, the same, or less than before the program, 58% of the experimental group subjects replied more, compared with 25% of the control group subjects. These comments suggest that participation in the community did increase after the treadmill and overground walking program.

CONCLUSION

After stroke, although most people are able to walk, many are only able to walk slowly and hesitantly. At the very least, this level of disability may mean that they are unable to walk fast or far enough to cross the road, while at worst they may be unable to even leave the house. This study found that after stroke people who participated in a training program, involving treadmill and overground walking focusing on increasing speed, step length, balance, fitness, and automaticity, gained and maintained improvements in walking speed, quality, and capacity. The routine provision of accessible, long-term, community-based walking programs based on these strategies should result in better ambulation after stroke. Improvements in ambulation provide the individual with the opportunities to participate in the community and, in addition, may indirectly reduce the burden on caregivers. Because other exercise programs have also resulted in improvements in function in persons residing in the community after stroke,[4,24-27] long-term exercise programs should become a priority. The challenge for health planners is to devise ways to implement ongoing programs that are accessible and affordable.

Acknowledgments: We acknowledge Anchalee Foongchomcheay, Mi-Joung Lee, and Doug Moore for their help with measurement.

References

1. Dean CM, Mackey FH. Motor Assessment Scale scores as a measure of rehabilitation outcome following stroke. Aust J Physiother 1992;38:31-5.
2. Jorgensen HS, Nakayama H, Raddschou HO, Olsen TS. Recovery of walking function in stroke patients: the Copenhagen Stroke Study. Arch Phys Med Rehabil 1995;76:27-32.
3. Hill K, Ellis P, Bernhardt J, Maggs P, Hull S. Balance and mobility outcomes for stroke patients: a comprehensive audit. Aust J Physiother 1997;43:173-80.
4. Duncan P, Richards L, Wallace D, et al. A randomized, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. Stroke 1998;29:2055-60.
5. Eng JJ, Chu KS, Dawson AS, Kim MC, Hepburn KE. Functional walk tests in individuals with stroke: relation to perceived exertion and myocardial exertion. Stroke 2002;33:756-61.
6. Green J, Forster A, Bogle S, Young J. Physiotherapy for patients with mobility problems more than 1 year after stroke: a randomised controlled trial. Lancet 2002;359:199-203.
7. Pohl M, Mehrholz J, Ritschel C, Ruckriem S. Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: a randomized controlled trial. Stroke 2002;33:553-8.
8. World Health Organization. International classification of impairments, disabilities and handicaps. Geneva: WHO; 1980.
9. Wade DT, Collen FM, Robb GF, Warlow CP. Physiotherapy intervention late after stroke and mobility. BMJ 1992;304:609-13.
10. Smith GV, Macko RF, Silver KH, Goldberg AP. Treadmill aerobic exercise improves quadriceps strength in patients with chronic hemiparesis following stroke: a preliminary report. J Neurol Rehabil 1998;12:111-7.

11. Smith GV, Silver KH, Goldberg AP, Macko RF. "Task-oriented" exercise improves hamstring strength and spastic reflexes in chronic stroke patients. Stroke 1999;30:2112-8.
12. Macko RF, Smith GV, Dobrovolny CL, Sorkin JD, Goldberg AP, Silver KH. Treadmill training improves fitness reserve in chronic stroke patients. Arch Phys Med Rehabil 2001;82:879-84.
13. Macko RF, DeSouza CA, Tretter LD, et al. Treadmill aerobic exercise training reduces the energy expenditure and cardiovascular demands of hemiparetic gait in chronic stroke patients. A preliminary report. Stroke 1997;28:326-30.
14. Silver KH, Macko RF, Forrester LW, Goldberg AP, Smith GV. Effects of aerobic treadmill training on gait velocity, cadence, and gait symmetry in chronic hemiparetic stroke: a preliminary report. Neurorehabil Neural Repair 2000;14:65-71.
15. Wagenaar RC, Beek WJ. Hemiplegic gait; a kinematic analysis using walking speed as a basis. J Biomech 1992;25:1007-15.
16. Saunders JB, Inman VT, Eberhart HD. The major determinants in normal and pathological gait. J Bone Joint Surg Am 1953;35:543-58.
17. Olney SJ, Griffin MP, Monga TN, McBride ID. Work and power in gait of stroke patients. Arch Phys Med Rehabil 1991;72:309-14.
18. Bowen A, Wenman R, Mickelborough J, Foster J, Hill E, Tallis R. Dual-task effects of talking while walking on velocity and balance following stroke. Age Ageing 2001;30:319-23.
19. Guyatt GH, Sullivan MJ, Thompson PJ, et al. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. Can Med Assoc J 1985;132:919-23.
20. van Straten A, de Haan RJ, Limburg M, Schuling J, Bossuyt PM, van den Bos GA. A stroke-adapted 30-item version of the Sickness Impact Profile to assess quality of life (SA-SIP30). Stroke 1997;28:2155-61.
21. Borg GA. Psychophysical scaling with applications in physical work of the perception of exertion. Scand J Work Environ Health 1990;16:55-8.
22. Grieve DW, Gear RJ. The relationship between length of stride, step frequency. Time of swing and speed of walking for children and adults. Ergonomics 1996;5:379-99.
23. Enright PL, Sherrill DL. Reference equations for the six-minute walk in healthy adults. Am J Respir Crit Care Med 2000;158: 1384-7.
24. Rodriguez AA, Black PO, Kile KA, et al. Gait training efficacy using a home-based practice model in chronic hemiplegia. Arch Phys Med Rehabil 1996;77:801-5.
25. Tangeman PT, Banaitis DA, Williams AK. Rehabilitation of chronic stroke patients: changes in functional performance. Arch Phys Med Rehabil 1990;71:876-80.
26. Werner RA, Kessler S. Effectiveness of an intensive outpatient rehabilitation program for postacute stroke patients. Am J Phys Med Rehabil 1996;75:114-20.
27. Dean CM, Richards CL, Malouin F. Task-related circuit training improves performance of locomotor tasks in chronic stroke: a randomized, controlled pilot trial. Arch Phys Med Rehabil 2000; 81:409-17.