Feasibility and Outcomes of a Community-Based, Pedometer-Monitored Walking Program in Chronic Stroke: A Pilot Study

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Background and **Purpose:** After stroke, many individuals have reduced physical activity. Pedometer use is reported to enhance physical activity in patients with other health conditions. The purpose of this study was to investigate the feasibility of a community-based, pedometer-monitored walking program and determine its effects on gait speed and distance, quality of life, and balance self-efficacy post stroke. **Methods:** A single-group, pretest-posttest follow-up design was used. Eleven individuals with chronic stroke (mean age, 60.4 years; mean time since stroke, 12.2 years) completed a pedometer-monitored, community-based intervention. Primary outcomes were the 6-minute walk test (6MWT) and 10-meter walk test. Secondary outcomes were the Activities-Specific Balance Confidence Scale, Stroke Impact Scale–16 (SIS-16), and a pedometer satisfaction survey. Subjects used pedometers daily for 6 weeks and recorded step counts, adverse symptoms, and exertion levels in exercise diaries. Weekly phone coaching was used to set walking goals. **Results:** No adverse events occurred. All subjects were able to don pedometers, 91% could read step counts, and 80% expressed satisfaction. There were no significant group changes across outcome measures. There were moderate effect sizes for changes in SIS-16 (0.312) and 6MWT (0.293). Increasing steps correlated with increased perception of physical function. **Discussion:** The results support the feasibility of and participant satisfaction with a community-based, pedometer-monitored walking program post stroke. Limitations include small sample size and lack of a comparison group. **Conclusions:** This study represents a preliminary step in determining the effectiveness of pedometer-based interventions for enhancing physical activity in persons with chronic stroke. Further study is warranted. **Key words:** *pedometers, stroke*

The sequelae of stroke reduce an individual's mobility and ability to participate in physical activity. Muscle weakness,[1-3] impaired peripheral blood flow,[4] balance deficits,[5] reduced gait velocity,[6,7] fatigue,[8] and decreased energy efficiency[9,10] may affect activity level. Physical deconditioning post stroke increases the risk of cardiovascular disease and is associated with higher mortality and morbidity rates.[11] Coronary artery disease[12] is reported in up to 75% of persons with stroke and results in cardiovascular fitness levels below those needed for daily activities.[13] After stroke, the percentage of individuals exercising regularly decreases,[14] and an estimated 58% do not meet recommended physical activity levels.[15] Physical capacity is reported to be approximately half that of age-matched healthy individuals,[11,16] and daily walking amount and intensity are well below those of age-matched, healthy adults.[5,17,18]

The benefits of physical activity in stroke prevention and rehabilitation have been well described. In healthy individuals, exercise decreases the risk of stroke by as much as 25%,[19-21] with a dose-response relationship between exercise and stroke risk suggested.[22,23] The American Heart Association's Scientific Statement on Physical Activity and Exercise Recommendations for Stroke Survivors concludes that "physical activity remains a cornerstone in the current armamentarium of risk-reduction therapies for the prevention and treatment of stroke."[24(p2039)] Exercise after stroke has been associated with improvements in gait speed and distance,[7,25-27] quality of life (QOL),[28,29] independence,[7] and energy expenditure.[24] In 2

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Top Stroke Rehabil 2014;21(2):101–110

www.strokejournal.com

doi: 10.1310/tsr2102-101

reviews, authors concluded that aerobic training after stroke significantly improves aerobic capacity, exercise tolerance, and cardiorespiratory fitness.[30,31] Although research to date has failed to establish a direct link between physical activity and subsequent stroke risk,[32] the multiple benefits compel providers to promote exercise after stroke.

Despite the reported benefits of exercise, individuals often assume a sedentary lifestyle after stroke.[33] Their fear of worsening their condition, lack of motivation, and poor self-efficacy may influence exercise behavior.[34,35] Training programs targeting fitness after stroke are generally delivered in laboratory or clinic settings, precluding participation for those with transportation or funding barriers.[36-38] Exercise equipment such as treadmills[37,39] or cycle ergometers[40,41] may not be available without added cost. Additional barriers to accessing outpatient rehabilitation have been described.[42] Although reimbursement for fitness services by third-party payers is increasing,[43] many do not offer coverage. For example, fitness services for Medicare beneficiaries are not often reimbursed[44] or may require out-of-pocket expenditures.[45] Despite these barriers, 84% of individuals express interest in exercising post stroke.[14]

A successful exercise intervention must minimize barriers and provide cost-effective programs that are within the capacity of individuals with stroke. The Centers for Disease Control and Prevention reports that walking is the most popular form of physical activity in America[46] and estimates that $5.6 billion in health care expenses could be saved if 10% of Americans began a walking program.[47] Pedometers are portable, relatively inexpensive devices that count steps by detecting motion at the hips. Two recent meta-analyses explored the effect of pedometers on physical activity and health.[48,49] These analyses included studies on healthy individuals and persons with respiratory[50] and coronary artery disease,[51] diabetes,[52] obesity,[53] and osteoarthritis.[54] The authors reported that pedometer use was associated with increasing steps taken per day and reductions in weight, body mass index, and blood pressure.[48,49] Community-dwelling individuals with stroke have low daily step counts (1,389 ± 797 steps/day), which is significantly correlated with poor aerobic conditioning and fatigue.[16] Pedometer-monitored training may be a suitable intervention after stroke, because approximately 70% of persons with stroke are able to walk.[6,7] User satisfaction with pedometers has been reported in multiple studies.[55-57] Further, pedometer interventions may address reported barriers to exercise because of availability, ease of use, and low cost.

The purposes of this pilot study were to investigate the feasibility of a community-based, pedometer-monitored walking program for persons with chronic stroke and to determine the effects of the program on gait speed, walking distance, health-related QOL, and balance self-efficacy.

Methods

This study utilized a single-group pretest-posttest design with a 3-month follow-up. The institutional review board approved the study. Participants provided informed consent before enrollment.

A convenience sample of individuals was recruited from a university-based stroke registry. Subjects were required to be 21 years old or older community-dwelling ambulators with stroke onset 6 months or more before participation.

Outcomes were assessed at baseline, after a 6-week intervention, and at 3-month follow-up. The primary outcomes were tests of walking speed and endurance including the following:

1. 6-minute walk test (6MWT), a measure of walking endurance, which has excellent test-retest reliability in persons with chronic stroke.[15,58]
2. 10-meter walk test—fast speed (10MWT), which has been used after stroke[59] and has excellent reliability.[60] Only 1 trial of this test is required to ensure reliable results.[61]

Secondary outcome measures included the following:

1. Activities-Specific Balance Confidence (ABC) Scale. This self-report measure assesses balance self-efficacy, has been used for persons with chronic stroke,[62] and has good validity and test-retest reliability.[63]
2. Stroke Impact Scale–16 (SIS-16). This self-report QOL measure captures an individual's perception of physical function after stroke. Reliability is excellent.[64]

3. Pedometer Satisfaction Survey. This 6-item, self-report measure captures satisfaction with pedometer use and has been utilized after stroke (see boxed material for survey questions).[65]

Pedometer Satisfaction Survey

1. Do you still have the pedometer?
   Yes/no
2. Do you still use the pedometer?
   Yes/no
3. Would you use the pedometer again?
   Yes/no
4. Would you recommend pedometer use for others?
   Yes/no
5. How easy was it to use the pedometer?
   1. very easy 2. easy 3. not hard or easy 4. hard 5. very hard
6. Are there any other comments you'd like to share?
   Yes/no

Note: Adapted from Carroll SL, Greig CA, Lewis SJ, et al. The use of pedometers in stroke survivors: Are they feasible and how well do they detect steps? *Arch Phys Med Rehabil.* 2012;933:466-470.

Participants were issued a pedometer (330 Step Pedometer; Sportline, Yonkers, NY). A pilot test of 7 of the study subjects established concurrent validity between visual step counts and step counts using the study pedometer as 0.605, and test-retest reliability was 0.99. A brief verbal educational module was provided to each participant addressing the benefits of exercise after stroke, pedometer use, and completion of daily exercise diaries. Participants were taught to use the Rate of Perceived Exertion (RPE) scale[66,67] and the signs and symptoms warranting medical attention (SWMA).[68] They were told that safe RPE values during walking should not exceed 13/20 or moderately intense activity. They were given a laminated pocket card with an RPE scale and a list of SWMA.

Participants were instructed to wear pedometers on the nonparetic hip (affixed by means of a belt or waistband)[65] during all waking hours, 7 days a week for 6 weeks. They recorded step count values, the highest RPE value achieved while walking that day, and any SWMA in their exercise diaries. During week 1, they were instructed to continue with normal daily activities; use exercise diaries; and record step counts, RPE scores, and any SWMA. At the end of week 1, they received the first of 5 weekly telephone coaching sessions. During these sessions, investigators used the decision-making process shown in **Figure 1** to collect data and assist with goal setting. Weekly step count goals were based on the data from the previous week. Participants were encouraged to increase the frequency of days on which they walked safely (without SWMA or with an RPE > 13).

Data analysis

Because this was a pilot study, no sample size calculation was performed. Mean group change scores for outcome measures were analyzed by using Friedman's test. Spearman's rank correlation coefficients were estimated to determine whether there were relationships between change scores and demographics (age, onset). Change scores were compared across gender using the Mann-Whitney *U* test. All analyses were performed in SAS 9.2 (SAS Institute, Cary, NC).

Results

Forty-seven individuals from a stroke registry were contacted; 15 agreed to be screened, and 11 subjects agreed to participate. Demographics and baseline scores for the participants are presented in **Table 1**.

All subjects completed the 6-week intervention. Ten subjects completed the 3-month follow-up; 1 subject had moved from the city at follow-up.

No SWMA were reported. All participants were able to don pedometers. One participant (#5) reported difficulty reading step counts. After week 4, that individual was issued a replacement pedometer and was re-instructed on how to use it. However, this participant was unable to provide step counts for weeks 4 to 6. All other participants were able to provide step counts each day of participation. Ten participants completed the pedometer satisfaction survey. Eight participants said they would use a pedometer again and would recommend it. Eight participants rated the pedometer as "easy" or "very easy" to use. Two reported continued use of the pedometer, whereas 3 felt that they did not need to use it because they were walking more frequently.

For 7 of 11 participants, average step counts across weeks 2 to 6 exceeded baseline values,

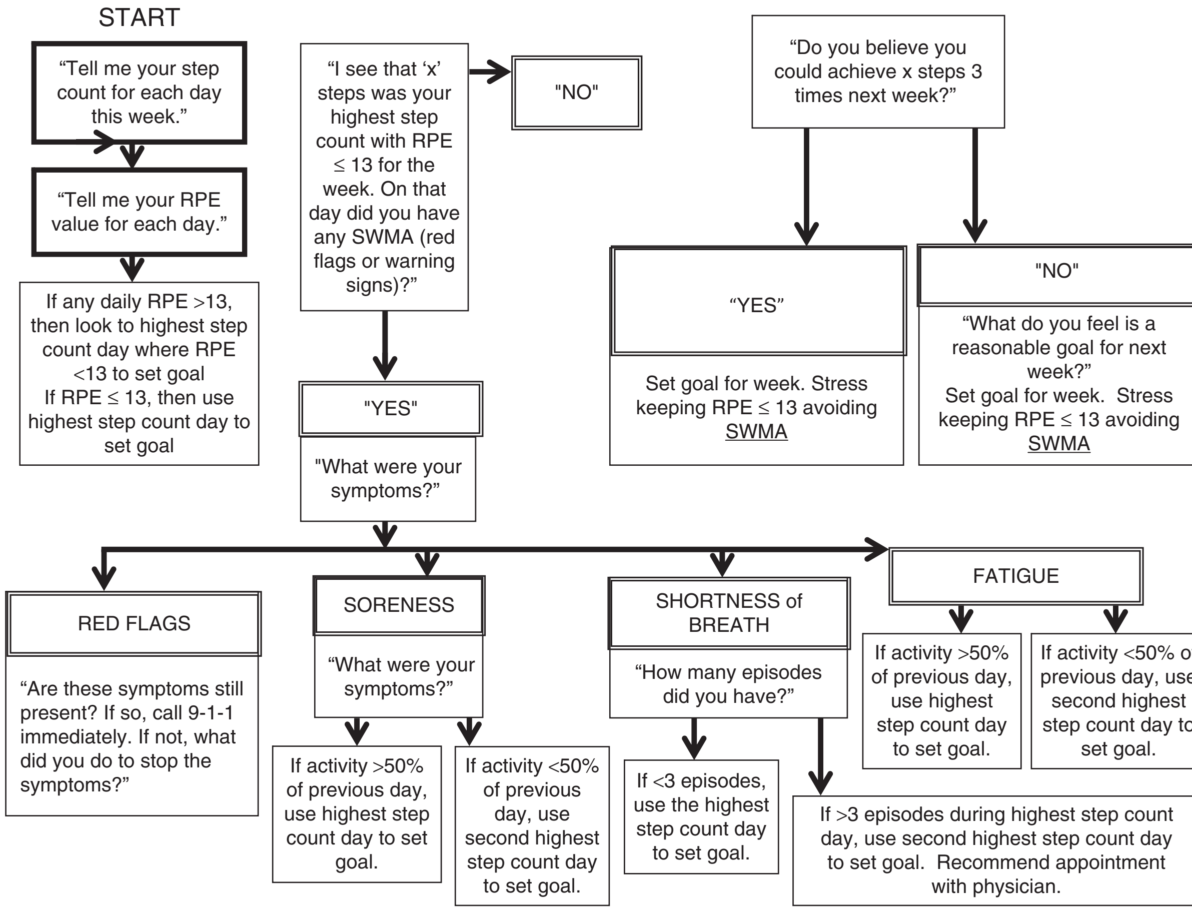

Figure 1. Decision tree used during weekly telephone coaching sessions. Participants reported daily step counts and Rate of Perceived Exertion (RPE) scale values. Participants were asked if they had experienced any signs and symptoms warranting medical attention (SWMA) on the day with the highest step count. If SWMA had been experienced or if RPE exceeded 13, participants were asked to describe the situation and actions taken. If the participants were still experiencing SWMA, they were instructed to go to the emergency department. A goal for the following week was set based on the highest daily step count without SWMA and RPE ≤ 13. Participants were asked if they could achieve that value 3 times the following week. If so, that value was used as the goal for the following week; if not, the participants were asked to set a goal that they felt was achievable.

although there was no statistical change across the 6 weeks (P = .388). **Figure 2** shows average weekly step counts for study participants.

At baseline, gait speed (10MWT) for all but 1 participant was below age/gender normative data for healthy individuals.[69] Although all participants reported being community ambulators, according to the speed-based classification system previously described for chronic stroke, 3 would be classified as household ambulators (< 0.4 m/s), 2 as limited community ambulators (0.4-0.8 m/s), and 5 as community ambulators (> 0.8 m/s).[70] Gait speed improved from pretest to posttest for 4 of 11 participants. **Table 2** shows pretest to posttest change scores. Although no participant changed categories on the speed-based classification system, the changes for 2 participants exceeded the substantial meaningful change of 0.1 m/s post stroke.[71] One additional participant achieved a change of 0.1 m/s between posttest and follow-up. The changes over time were not statistically significant (P = .509). Baseline gait speed was inversely related to years since stroke (r = −0.702, P = .016) as well as the average number of steps per day from baseline (r = −0.636, P = .035).

Table 1. Participant demographics and baseline scores

						Baseline scores			
ID	Age, years	Gender	Years since stroke	Side of stroke	Assistive device	Gait speed fast, m/s	6 MWT distance, m	ABC score	SIS-16 score
1	41	M	1.5	L	AFO	0.79	213.4	45.63	55
2	61	F	9.5	L	None	1.89	512.9	86.88	74
3	87	M	7	L	Straight cane, AFO	0.27	108.9	35.62	51
4	66	M	9	L	Quad cane, AFO	0.23	63.8	57.8	58
5	64	M	3	L	Straight cane, AFO	0.19	58.1	55.31	54
6	46	M	13	L	Straight cane	0.78	191	86.88	69
7	65	M	15	R	AFO	1.09	285.1	93.75	76
8	57	F	24	L	Straight cane, AFO	1.19	261.4	40.62	48
9	58	F	25	R	None	1.36	373.7	90.94	75
10	53	F	17.8	R	None	1.15	237.7	52.5	61
11	66	F	9	R	Straight cane	0.61	168.4	69.38	68
Mean (*SD*)	60.4 (12.1)		12.2 (7.7)			0.87 (0.53)	224.95 (134.87)	65.03 (21.47)	62.64 (10.18)

Note: ABC = Activities Specific Balance Confidence; AFO = ankle-foot orthosis; 6MWT = 6-minute walk test; SIS-16 = Stroke Impact Scale–16; 10MWT = 10-meter walk test.

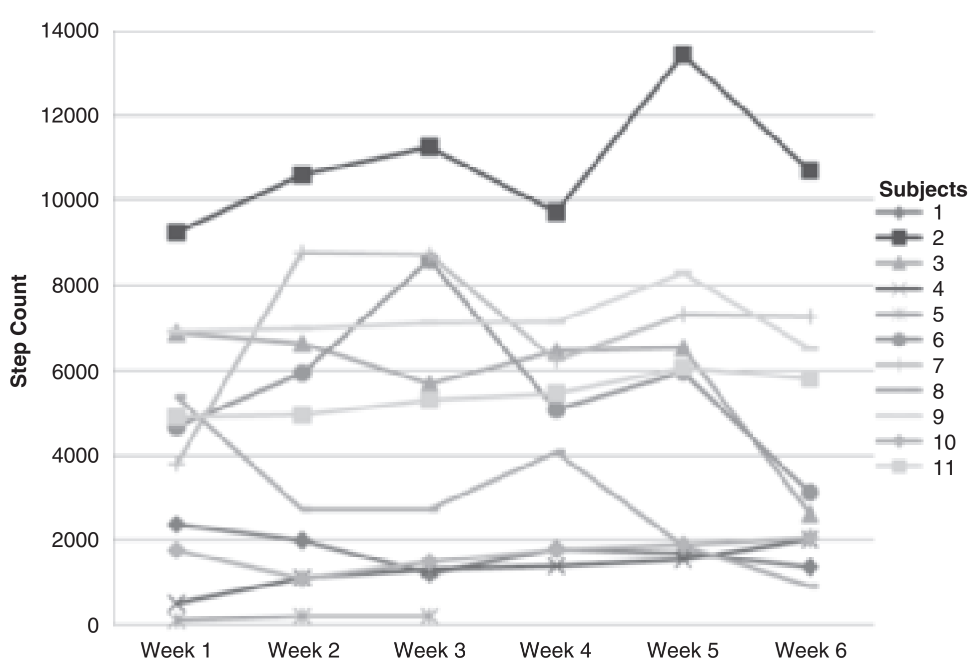

Figure 2. Mean daily step counts for participants.

Table 2. Pretest to posttest change scores

Subject ID	10MWT (fast) change, m/s	6 MWT distance change, m	ABC change scores	SIS-16 change scores
1	0	34.75	11.87	0
2	0.01	-93.58	-2.5	0
3	0	-80.59	-6.87	-5
4	0	16.75	-20.3	5
5	0	4.59	14.07	6
6	-0.14	-128.16	-5.63	0
7	0.01	-52.16	-10	0
8	-0.11	-107.66	19.38	12
9	0.12	2.42	1.86	0
10	-0.07	-61.17	2.5	-3
11	0.13	181.75	1.87	1
Mean	0.00	-25.73	0.57	1.45
(SD)	0.08	87.75	11.49	4.66

Note: ABC = Activities Specific Balance Confidence; 6MWT = 6-minute walk test; SIS-16 = Stroke Impact Scale–16; 10MWT = 10-meter walk test.

All participants' baseline 6MWT distances were below mean distances for community-dwelling individuals older than 60 years.[72, 73] Two participants' baseline values exceeded the mean 6MWT distance for individuals with chronic stroke.[73] Walking distance improved from pretest to posttest for 5 of 11 participants. The change for 1 participant exceeded both the reported minimal detectable change (MDC) of 36.6 m[58] and the minimal clinically important difference (MCID) of 50 m.[71] From posttest to follow-up, 7 participants improved 6MWT; 1 change exceeded the MDC, and an additional participant showed change exceeding the MCID.[71] From pretest to follow-up, 4 participants increased their 6MWT. Two participants exceeded the MDC and MCID.[58] Like speed, distance was not different across the 3 times (P = .634), and baseline gait speed was significantly related to time since stroke onset (r = 0.674, P = .023) and average number of steps per day (r = 0.627, P = .039).

At baseline, 6 participants scored below the mean ABC score for chronic stroke[74]; 7 were below the cutoff score indicating fall risk after stroke.[75] At posttest, 6 participants' scores had improved; however, 5 had scores that remained below fall risk cutoff levels. ABC scores did not significantly change over the study period (P = .294).

The group mean baseline SIS-16 score of 62.64 was consistent with what has been reported in persons with chronic stroke[76] but below the reported falls risk cutoff score of 61.7.[75] Despite the fact that 4 participants had improved scores at posttest and 6 participants had improved scores at follow-up, all scores remained below the falls risk cutoff score. None of these change scores exceeded reported MCID values of 9.4 to 14.1 depending on anchor,[77] and differences were not statistically significant (P = .261).

There was a positive relationship between step increase and posttest SIS-16 score (r = 0.822, P = .002), which persisted at follow-up (r = 0.745, P = .021), as well as a positive relationship between step increase and posttest ABC score at posttest (r = 0.609, P = .047) and at follow-up (r = 0.624, P = .054). The relationships between step increase and gait speed and endurance were less impressive (r = -0.255, P = 0.450 and r = 0.245, P = 0.467, respectively) at posttest, although the relationship strengthened for gait endurance at follow-up (r = 0.261, P = .467). Moderate effect sizes, defined as mean change divided by the standard deviation, were found for changes in SIS-16 (0.312) and 6MWT (0.293). Additionally, increases in steps correlated with increases in perceived physical function (SIS-16).

Discussion

To our knowledge, this is the first report of a pedometer-monitored, community-based intervention after stroke. Pedometers are appropriate to use after stroke, minimizing previously reported barriers to exercise.[34,35] This intervention coincides with recommendations from a recent study in which patients were advised to increase the number of daily walking bouts in both the home and the community.[18] The pedometers used in this study are inexpensive, costing $14.99. Participants were able to walk in their homes and communities, alleviating transportation costs.

This study demonstrates the feasibility of pedometer use for community-dwelling individuals after stroke. Although a recent study indicated that 10% of stroke participants needed assistance to don pedometers and could not read step counts, [65] all our participants could don pedometers and 91% could read step counts. A total of 73% of those screened agreed to participate, and 80% of those said they would use the pedometer again, consistent with what has previously been reported.[65] Several participants initially had difficulty using the numerical RPE scale, so investigators added language to the scale (eg, "moderate" intensity). All participants were offered pedometers after the completion of the study, and 6 participants accepted them. Participant 4, whose baseline step count was 523, remarked, "…6 or 7 months after its [the study's] completion, I am doing about 2,800 steps [when I stay home] and 3,800 steps [when I go out]. It's amazing what one little inexpensive gadget and the guidance … can do. [I now use] a spreadsheet, which tracks the progress I made."

This study incorporated 2 key elements reported to contribute to successful pedometer intervention: goal setting and an exercise diary.[48,78] Weekly goal setting was safely done on the basis of previous activity levels completed without SWMA, within RPE levels that have been reported to be appropriate for individuals after stroke.[24,79] Most participants increased step counts beyond levels achieved during the baseline week.

The main limitation of our pilot study was the small sample size, which limits generalizability. The heterogeneity of participants may have affected results. Our study was conducted in a large metropolitan area, so results may not be generalizable to rural settings. The mean length of time since stroke onset of our participants was 12.2 years. Exercise behaviors may have been well established and, therefore, less amenable to change at this time. In our labs, we are beginning to explore the effectiveness of this intervention in an acute poststroke population.

Concern has been expressed regarding the accuracy of pedometer-counted steps with individuals who walk more slowly than 0.5 m/s,[65] yet others have not reported a strong association between pedometer step counts and gait speed in persons with neurological diagnoses.[80] However, our pilot data indicate high reliability and validity using the study pedometer with our target population. Another limitation is the possibility of a ceiling effect. At baseline, 5 participants exceeded the average steps per day taken by Americans.[81] All but 2 exceeded the average step count reported for community-dwelling individuals with chronic stroke.[16]

The intervention may not have been of sufficient duration for a meaningful effect. The pedometer interventions reported in a recent meta-analysis had a median duration of 16 weeks.[49] In addition, participants were not encouraged to set a goal for higher step counts, only for greater frequency of matching their highest weekly reported step count.

Pedometers may not have collected sufficient detail. Accelerometers provide additional information about intensity of physical activity.[82] In individuals with neurological dysfunction, accelerometers have been shown to be able to differentiate between activities based on intensity; allow for assessment of "wear time"; and record minutes spent in light, moderate, and vigorous exercise.[24] Although accelerometers provide additional information, their cost is higher. In this study, pedometers were used because it was felt that these low-cost devices are likely to be available for a greater number of individuals who have experienced stroke. Future studies might incorporate both pedometers and accelerometers to better determine the most appropriate interventions. In addition, data about participant activity and negative incidents, such as losses of balance or falls, would be useful to capture in future trials.

Conclusions

This study demonstrates the feasibility of using pedometers in a community-dwelling chronic stroke population. As such, it represents a preliminary step that will assist in determining the effectiveness of a pedometer-based intervention for enhancing physical activity in persons with chronic stroke. Further study of this intervention is warranted.

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