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ORIGINAL RESEARCH

# Reducing Sitting Time After Stroke: A Phase II Safety and Feasibility Randomized Controlled Trial

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**Abstract**

**Objective:** To test the safety, feasibility, and effectiveness of reducing sitting time in stroke survivors.

**Design:** Randomized controlled trial with attention-matched controls and blinded assessments.

**Setting:** Community.

**Participants:** Stroke survivors (N=35; 22 men; mean age, 66.9±12.7y).

**Interventions:** Four counseling sessions over 7 weeks with a message of sit less and move more (intervention group) or calcium for bone health (attention-matched control group).

**Main Outcome Measures:** Measures included safety (adverse events, increases in pain, spasticity, or fatigue) and feasibility (adherence to trial protocol). Secondary measures included time spent sitting (including in prolonged bouts ≥30min), standing, and stepping as measured by the thigh-worn inclinometer (7d, 24h/d protocol) and time spent in physical activity of at least moderate intensity as measured by a triaxial accelerometer. The Multimedia Activity Recall for Children and Adults was used to describe changes in use of time.

**Results:** Thirty-three participants completed the full protocol. Four participants reported falls during the intervention period with no other adverse events. From a baseline average of 640.7±99.6min/d, daily sitting time reduced on average by 30±50.6min/d (95% confidence interval [CI], 5.8−54.6) in the intervention group and 40.4±92.5min/d in the control group (95% CI, 13.0−93.8). Participants in both groups also reduced their time spent in prolonged sitting bouts (≥30min) and increased time spent standing and stepping.

**Conclusions:** Our protocol was both safe and feasible. Participants in both groups spent less time sitting and more time standing and stepping postintervention, but outcomes were not superior for intervention participants. Attention matching is desirable in clinical trials and may have contributed to the positive outcomes for control participants.

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Between 1990 and 2010 worldwide prevalence rates for stroke increased by 84% (by 27% in high-income countries), making stroke the third leading cause of disability.[1] Up to a third of people who survive a first stroke will suffer a recurrent stroke within 5 years, with this figure increasing to 43% for people surviving ≥10 years.[2] Both lack of adequate levels of physical activity and high sedentariness (ie, too much sitting) in this population are likely contributing factors to recurrent stroke rates. Lack of adequate physical activity (<150min/wk of moderate-to-vigorous physical

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activity [MVPA]) is the second highest population attributable risk factor for stroke,[3] whereas spending long periods of the day sitting down, particularly in long bouts of uninterrupted sitting, is an independent risk factor for cardiovascular disease, morbidity, and mortality in otherwise healthy adults, even after taking into account the time spent in MVPA.[4,5] Studies have shown that people with stroke are typically both highly sedentary and physically inactive,[6-11] placing them at the greatest risk of the consequences arising from these conditions. In a recently completed observational study using high precision activity monitors, people with stroke were more sedentary and less activity than age-matched controls, spending 75% of their waking hours sitting down each day and <5min/d in MVPA.[6]

Experimental studies[12] and epidemiologic studies[13] have shown that breaking up sitting time with periods of light intensity physical activity (eg, walking at a comfortable pace) leads to reductions in cardiovascular disease risk factors[12] and mortality.[13] Therefore, interventions aimed at reducing daily sitting time may be a promising new target for reducing recurrent stroke risk. However, there are many reasons why people with stroke spend long periods sitting down, including mobility impairments, post-stroke fatigue, pain, and spasticity. This means that people with stroke may find it difficult to sit less each day. Furthermore, encouraging people with stroke to move more each day may lead to increased exposure to risk of falls.

The aim of this pilot randomized controlled trial was to assess the safety, feasibility, and effectiveness of an intervention to reduce sitting time in people with stroke. Our primary hypotheses were that the intervention would be both safe (not lead to adverse events, including falls, negative changes in pain, spasticity, and fatigue) and feasible (have a high adherence to the measurement protocol, in particular the activity monitor wear time). Our secondary hypotheses were that the intervention would lead to a reduction in sitting time, a reduction in prolonged sitting time (bouts ≥30-min duration),[14] and an increase in standing and stepping time and time spent in MVPA. We considered a 30-min/d reduction in sitting time as the minimal clinically important difference. In healthy, inactive adults, replacing 1h/d of self-reported sitting with light-intensity activity has been linked to lower all-cause mortality.[13] As the dose-response relation between sedentary physical activity and health is nonlinear,[13] it is possible that even smaller reductions in sitting time will have health benefits for people who are both more sedentary (spend more time sitting) and more inactive (spend less time in MVPA), particularly when measured accurately and objectively as opposed to self-report.

## Methods

This was a pilot randomized controlled trial with an attention-matched control group, concealed allocation, and blinded assessment of outcome. The trial was registered with the Australian and New Zealand Trial Registry (ACTRN12612000958886). Participants were unaware of the intervention of interest. They were told only that this was a trial of healthy living after stroke. A 1:1 randomization sequence was prepared by a statistician independent of the project. A research assistant independent of the project prepared a set of sequentially numbered, opaque, sealed envelopes with the group allocation inside. Participants were recruited from outpatient clinics, databases of participants from previous trials, stroke exercise classes, and social media. Research staff repeatedly visited outpatient clinics and stroke exercise classes to identify potential participants. Flyers were also placed in clinics, and frequent phone calls were made to therapy staff within these centers to assist in recruitment. A trained assessor who was unaware of group allocation assessed participants at baseline (pre-intervention) and postintervention. Ethical approval was obtained from the relevant ethics committees, and participants provided written, informed consent. Because the primary outcomes were safety and feasibility, we did not power the trial to detect statistically significant changes in sitting time. Changes in sitting time were interpreted in light of what we considered the minimal clinically important difference in daily sitting time (30min/d).[13]

***List of abbreviations:***

| | |
|---|---|
| **CI** | **confidence interval** |
| **MARCA** | **Multimedia Activity Recall for Children and Adults** |
| **MVPA** | **moderate-to-vigorous physical activity** |

### Participants

We recruited people living at home after stroke. Inclusion criteria were as follows: at least 6 months since last stroke (to minimize the impact of rapid improvement in functional recovery after stroke); living at home for at least 3 months since last hospital discharge; some residual walking and/or balance deficits (self-reported); and sufficient cognitive and language ability to provide informed consent and participate in the motivational interviewing sessions.

### Intervention

Participants were randomly assigned to the intervention or control group. Participants in the intervention group received a series of 4 counseling sessions with the main message being to sit less and move more, with encouragement to regularly break up sitting time with short bursts of light-intensity activity (standing, walking at a comfortable pace). Interventions specifically targeted at reducing sitting time have been found to be more effective than those aimed at general lifestyle advice or advice to increase MVPA.[15] The counseling sessions were provided by 2 researchers (C.E., E.B.), both of whom were formally trained in motivational interviewing techniques through accredited courses. Motivational interviewing is a form of goal-directed counseling that aims to strengthen a person's own motivation and commitment to change and is particularly effective in eliciting behavior change for people who are reluctant or ambivalent about change.[16] The first session was provided face-to-face in the participant's home. At this first session, participants were presented with an individualized written report which provided feedback regarding daily sedentary time and breaks in sedentary time based on the baseline hip-worn accelerometer data. This report was used as the starting point for discussions. The counseling sessions used key motivational interviewing techniques (decisional balance sheets, importance and confidence rulers) to initiate and reinforce change talk. Action plans, goals, and strategies were elicited from the participants, rather than imposed by the counselors. Follow-up counseling sessions were delivered by phone and occurred 1, 3, and 7 weeks after the initial session. We chose to deliver the intervention via a face-to-face home visit and follow-up telephone calls, rather than in groups to avoid transport being a barrier to participation.[17] To match the groups for

attention, control group participants received the same schedule of interviews, with a placebo message of increasing calcium for bone health. Data from a food frequency questionnaire were used to create personalized feedback for control participants.[18] The food frequency questionnaire was used to reinforce the credibility of the attention-matched control group, and data were not analyzed.

## Outcome measures

Baseline measures were collected at the first face-to-face appointment and included stroke type (Oxfordshire Stroke Classification[19]), stroke severity (National Institutes of Stroke Scale; score range, 0−42, with higher scores indicating more severe stroke), side of stroke, height, weight, walking speed (self-selected, measured over the middle 5 m of a 9-m walkway), use of walking aids, living arrangements (alone/with spouse), degree of independence in activities of daily living (self-reported as independent or requiring some assistance in daily tasks, such as showering, dressing, and cooking), and cognitive function (Montreal Cognitive Assessment; score range, 0−30, with scores <22 indicating cognitive dysfunction[20]). All participants completed a food frequency questionnaire.[18] At this appointment, participants were fitted with 3 activity monitors and provided with instructions regarding keeping diaries of sleep/wake time and when monitors should be removed. Participants wore all 3 monitors for 7 days at baseline and again 1 week after the final counseling session (postintervention).

### Safety

Safety was assessed by recording changes in self-reported pain and spasticity (visual analog scale, anchored at 0 [no pain/spasticity] and 10 [severe pain/spasticity]) and fatigue (Checklist Individual Strength; score range, 8−56, with higher scores indicating greater fatigue symptoms[21]). Falls incidence and any other adverse events were ascertained by asking structured questions (Have you fallen or tripped over in the last 2mo?) at each assessment point. Although simple recall of falls can underestimate falls incidence, it does not underestimate injurious falls (specificity, 87%−100%).[22]

### Feasibility

Feasibility was assessed via adherence to counseling sessions (actively engaged in all scheduled counseling sessions) and completion of all assessments at baseline and postintervention, including activity monitor wear time.

### Time spent sitting, standing, and stepping

Time spent sitting, standing, and stepping was measured using the activPAL3 device,[a] which was waterproofed and attached to the participants' anterior thigh on the nonhemiparetic leg. Participants wore this monitor continuously (24h/d) for 7 days, including during showering/bathing and water-based activities. The activPAL3 contains an inclinometer and a triaxial accelerometer. In studies of both healthy adults and people with stroke, it has been shown to be 99% to 100% accurate in classifying sitting/lying and standing postures.[23,24] The activPAL3 data were processed using activPAL3 software (version 7.2.32).[a] Sleep/wake diaries were entered into a Microsoft Access database.[b] A custom-built SAS program linked activPAL3 data to the sleep/wake diaries to identify and remove sleep and nonwear time. This program also identified periods of prolonged, uninterrupted sitting of ≥30-minutes duration.

### Physical activity

Physical activity was measured using the Actigraph GT3+ triaxial accelerometer,[c] which was worn on an elastic waist belt and positioned over the nonhemiparetic hip. Participants were asked to wear the monitor 24h/d for 7 days, removing it for showering/bathing or any other water-based activities. Participants also wore the Sensewear arm band[d] around their nonhemiparetic upper arm. In this trial, the Sensewear arm band was used purely to determine nonwear time for the Actigraph. Because the Sensewear arm band switches off when not in contact with the skin and also had to be removed for water-based activities, we made the assumption (backed up by review of participant diaries) that the Actigraph and Sensewear monitors were always removed at the same time. Actigraph data were processed by ActiLife software (version 6.3.2),[c] and periods of sleep (matched to activPAL data) and nonwear (as detected by the Sensewear arm band) were removed using custom filters. In line with the most commonly used cut points for classification of activity intensity of older adults,[25] activity of at least moderate intensity was defined as ≥1952 counts per minute.[26]

### Use of time

Use of time was measured using the Multimedia Activity Recall for Children and Adults (MARCA).[27] This computerized use of time tool asks participants to recall their previous day from midnight to midnight and classifies activities according to a predetermined list of 520 separate items. Activities are then classified into time spent in various superdomains (eg, transport, screen time, chores). The superdomains are further categorized into macrodomains (eg, active and passive transport, computer and television time). Participants were phoned at a predetermined time during the week they were wearing the monitors at baseline and postintervention, and the MARCA was administered by interview, which took approximately 20 minutes. In a previous observational study, agreement between repeated administration of the MARCA on the same day ranged from .834 (95% confidence interval [CI], .681−.918) to .946 (95% CI, .890−.974) for the different MARCA superdomains.[6] The MARCA has been validated against doubly labeled water in young adults, with a correlation of $r=.70$ for daily energy expenditure.[28]

## Statistical analyses

Paired $t$ tests (or Wilcoxon signed-rank tests where data were not normally distributed) were used to examine within-group differences between baseline and postintervention in safety and feasibility measures (pain, spasticity, fatigue, monitor wear time, and falls). To adjust for waking hours, activPAL3- and Actigraph-derived activity variables (time spent in sitting, prolonged sitting, standing, stepping, and MVPA) were standardized to a 16-h/d waking wear time period. Paired $t$ tests (or Wilcoxon signed-rank tests where data were not normally distributed) were used to examine within-group differences between baseline and postintervention in activity variables. Univariate analyses of variance (with adjustment for multiple comparisons) were used to examine between-group differences in change scores (postintervention minus baseline) in time spent sitting, standing, stepping, and MVPA. Independent $t$ tests were used to examine between-group differences in MARCA-derived variables between the intervention and control groups. Sequential Bonferroni corrections were applied to account for multiple comparisons. All analyses were by intention to treat.

## Results

Participants were recruited between February 2013 and February 2014, with final data collected in May 2014. Figure 1 presents the flow of participants through the trial. Table 1 presents baseline characteristics of the 35 participants. Four (intervention: n=2; control: n=2) participants reported falls during the intervention period. None of the falls were injurious. There were no other adverse events reported. Pain, spasticity, and fatigue did not change between baseline and postintervention for either group (table 2). Compliance with wearing the activity monitors was high. At baseline, 23 and 31 participants had 7 days of valid data from the activPAL3 and Actigraph monitors, respectively. All other participants had at least 4 days of wear time for both monitors, with the exception of 3 participants for whom the Actigraph monitor did not record any valid data on any days. At postintervention, 33 and 25 participants had 7 days of valid data from the activPAL3 and the Actigraph monitors, respectively. All other participants had at least 4 valid wear days for both the activPAL3 and Actigraph monitors, with the following exceptions:

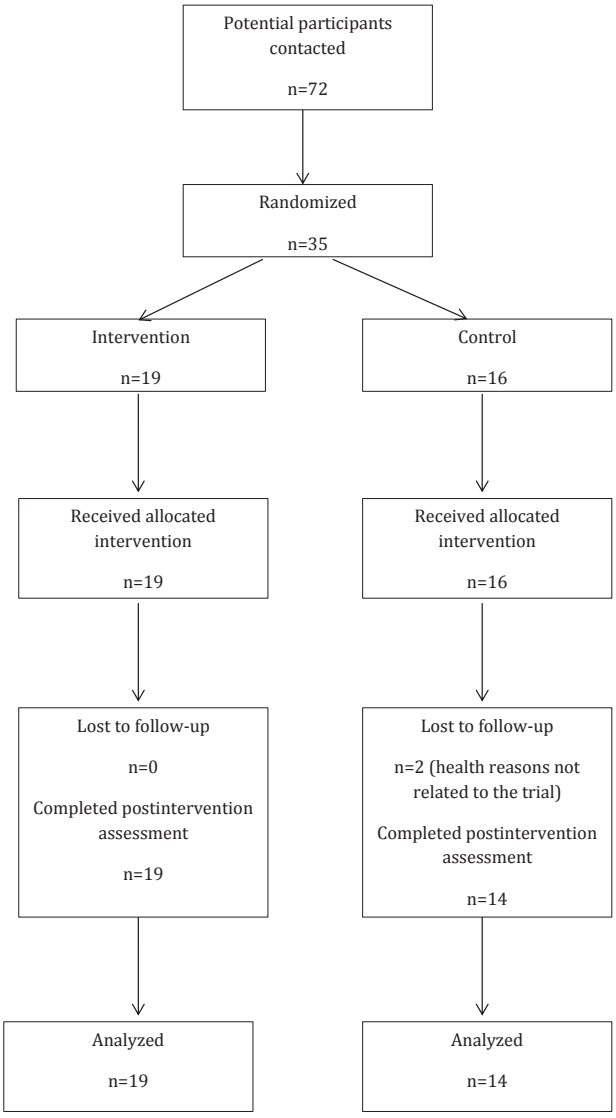


**Fig 1** Consolidated Standards of Reporting Trials statement flowchart.

**Table 1** Participant characteristics

| Characteristic | Whole Sample (N=33) | Intervention Group (n=19) | Control Group (n=14) |
|---|---|---|---|
| Age (y) | 66.9±12.7 | 65.4±12.3 | 67.8±13.8 |
| Males | 22 (62.9) | 13 (68.4) | 9 (64.3) |
| First stroke | 28 (80.0) | 12 (63.2) | 14 (100) |
| Stroke type* | | | |
| TACI | 6 (17.1) | 5 (26.3) | 1 (7.1) |
| PACI | 13 (37.1) | 9 (47.4) | 3 (21.4) |
| LACI | 7 (20) | 3 (15.8) | 4 (28.6) |
| Hemorrhage | 9 (25.7) | 2 (10.5) | 6 (42.9) |
| Stroke severity score (NIHSS) | | | |
| No symptoms (0) | 6 (17.1) | 3 (15.8) | 3 (21.4) |
| Mild (1–4) | 20 (57.1) | 11 (57.9) | 7 (50.0) |
| Moderate/severe (>4) | 9 (25.7) | 5 (26.3) | 4 (28.6) |
| Time since stroke (y) | 3.2±3.4 | 2.8±2.6 | 4.1±4.3 |
| Living arrangement | | | |
| Spouse/other | 27 (77.1) | 14 (73.7) | 12 (85.7) |
| Alone | 8 (22.9) | 5 (26.3) | 3 (14.3) |
| Independence in ADLs | | | |
| Independent | 23 (65.7) | 14 (73.7) | 7 (50.0) |
| Requires assistance | 12 (34.3) | 5 (26.3) | 7 (50.0) |
| Use of walking aid | | | |
| No aids | 23 (65.7) | 13 (68.4) | 9 (64.3) |
| Walking stick | 10 (28.6) | 5 (26.3) | 4 (28.6) |
| Frame | 2 (5.7) | 1 (5.3) | 1 (7.1) |
| Walking speed (m/s) | 0.81±0.41 | 0.80±0.36 | 0.82±0.51 |
| BMI (kg/m$^2$) | 28.6±4.8 | 29.3±5.8 | 27.5±3.0 |
| MoCA score | 24.2±3.6 | 24.0±4.2 | 24.4±2.7 |

NOTE. Values are mean ± SD or n (%).
Abbreviations: ADL, activities of daily living; BMI, body mass index; LACI, lacunar infarct circulation infarct; MoCA, Montreal Cognitive Assessment; NIHSS, National Institutes of Health Stroke Scale; PACI, partial anterior circulation infarct; TACI, total anterior circulation infarct.
* Oxfordshire Stroke Classification.

2 participants (both in the control group) did not complete the postintervention assessment for reasons of ill health not related to the trial, and a further 3 participants did not have any valid wear days for the Actigraph monitor. Table 2 presents average wear days and monitored hours for all of the participants. There was 100% compliance with counseling sessions (ie, all participants engaged in all scheduled counseling sessions).

At baseline, participants spent an average of 640.7±99.6min/d sitting, 436.2±147min/d in prolonged sitting (uninterrupted sitting bouts of ≥30min), 153.6±63.9min/d standing, 59.3±36.8min/d stepping, and 7.4±8.6min/d in MVPA. Table 3 presents baseline and follow-up values for the intervention and control groups (unadjusted for wear time). Table 4 presents data standardized to a 16-hour waking wear time, including within-group and between-group effects. Here, daily sitting time reduced on average by 30.0±50.6min/d (95% CI, 5.8–54.6) in the intervention group and 40.4±92.5min/d (95% CI, 13.0–93.8) in the control group. Prolonged sitting time reduced on average by 36.1±65min/d (95% CI, 4.8–67.5) in the intervention group and 44.2±134.2min/d (95% CI, 33.3–121.7) in the control group. Reductions in sitting time were replaced with increases in time spent standing (intervention: 22.5±35.5min/d; control: 33.8±59min/d) and stepping (intervention: 7.8±19.2min/d;

**Table 2** Safety and feasibility measures

| Outcomes | Intervention Group | | Control Group | |
|---|---|---|---|---|
| | Baseline (n=19) | Postintervention (n=19) | Baseline (n=14) | Postintervention (n=14) |
| Pain, VAS (cm) | 3.4±2.8 | 3.2±3.1* | 3.7±3.5 | 3.4±3.3* |
| Spasticity, VAS (cm) | 3.0±2.8 | 2.4±2.4* | 3.6±3.2 | 3.8±2.7* |
| Fatigue score, CIS | 34.1±9.3 | 32.3±8.3† | 32.9±11.7 | 35.3±10.7† |
| No. of falls‡ | | | | |
| 0 | | 16 (84.2) | | 11 (78.6) |
| 1 | | 1 (5.3) | | 1 (7.1) |
| 2 | | 1 (5.3) | | 1 (7.1) |
| Missing | | 1 (5.3) | | 1 (7.1) |
| No. of valid wear days activPAL3 | 6.1±0.8 | 6.9±0.2 | 5.6±0.9 | 6.9±0.4 |
| Waking wear hours§ activPAL3 (h/d) | 14.4±1.2 | 14.1±1.3 | 14.1±1.2 | 14.0±1.6 |
| No. of valid wear days Actigraph | 6.5±0.9 | 6.6±0.8 | 6.7±0.6 | 6.8±0.6 |
| Waking wear hours§ Actigraph (hr/d) | 14.6±1.1 | 14.1±1.4 | 14.5±1.5 | 14.2±1.4 |

NOTE. Values are mean ± SD or n (%).
Abbreviations: CIS, Checklist Individual Strength; VAS, visual analog scale.
* No significant difference, Wilcoxon signed-rank test.
† Significant difference, paired *t* test.
‡ Number of falls reported during the intervention period.
§ Waking hours monitored.

control: 6.6±9.9min/d). No differences were statistically significant after sequential Bonferroni adjustments. On average, both intervention and control group participants exceeded the target of reducing sitting time by at least 30min/d, with effect sizes of .62 and .46, respectively. At <10min/d, average time spent in MVPA (Actigraph data) remained very low for all participants at baseline and postintervention. Regarding reported use of time (MARCA data), participants reported reductions in sedentary activities, in particular television viewing (−46 and −38min/d for the intervention and control groups, respectively), but there were no significant between-group differences in any of the domains (table 5).

## Discussion

Stroke survivors are both sedentary (spending large proportions of their day sitting down), and physically inactive. Previous research has largely focused on encouraging stroke survivors to increase their time in physical activity of at least moderate intensity. This is the first clinical trial to investigate an intervention aimed at encouraging stroke survivors to replace sitting time with light-intensity activity (ie, sit less and move more). Our protocol was both safe and feasible, with no adverse events (apart from 4 noninjurious falls: 2 in the control group, and 2 in the intervention group) and high compliance. On average, participants in both groups reduced their sitting time by at least 30min/d and replaced sitting time with standing and stepping. However, there was considerable intraindividual variability in the magnitude of change, and participants in the intervention group did not show superior outcomes relative to the control group.

The trial was not powered to detect statistically significant intervention effects. However, the attention-matched control group may have played a role in the lack of between-group differences. Participants in the control arm of the trial received the same number of counseling sessions as intervention participants. In an attempt to further reduce bias, participants were unaware of the intervention of interest; they were told the trial was about healthy living after stroke and that they would receive counseling based on either diet or exercise. Although the content of the counseling sessions in the control group focused on a dietary message, anecdotally many participants reported changing physical activity habits (eg, going for more regular walks, recommencing gym programs). The activity monitors worn by all participants did not provide any real-time feedback; however, it is possible that they could have impacted on activity levels in all participants. Determining the key active elements in any intervention is important.

**Table 3** Sitting time and physical activity

| Outcomes | Intervention Group (n=19) | | Control Group (n=14) | |
|---|---|---|---|---|
| | Baseline | Postintervention | Baseline | Postintervention |
| Total sitting time (min/d) | 645.8±99.9 | 609.7±121.0 | 633.8±102.5 | 589.9±111.5 |
| Sitting time accumulated in bouts ≥30min (min/d) | 431.1±155.7 | 396.0±177.3 | 443.2±139.8 | 396.4±162.6 |
| Standing time (min/d) | 154.8±66.8 | 171.3±73.9 | 151.9±62.1 | 183.5±90.8 |
| Stepping time (min/d) | 59.6±40.6 | 64.3±45.0 | 59.0±32.4 | 65.5±42.3 |
| MVPA, ≥1952 cpm (min/d) | 8.2±10.5 | 6.6±9.5 | 6.6±5.9 | 9.9±10.4 |

NOTE. Values are mean ± SD, not adjusted for wear time.
Abbreviation: cpm, counts per minute.

**Table 4** Sitting time and physical activity, standardized to 16-h/d waking wear time

| Outcomes | Intervention Group (n=19) | | Control Group (n=14) | | Difference Within Groups (postintervention−baseline*) | | | | Difference Between Groups in Change Scores (intervention−control†) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Postintervention | Baseline | Postintervention | Intervention (n=19) | P | Control (n=14) | P | | P |
| Total sitting time (min/d) | 722.3±107.5 | 692.1±124.8 | 720.7±99.5 | 680.2±133.1 | −30.2±50.6 (−54.6 to −5.8) | .018 | −40.4±92.5 (−93.8 to 13.0) | .126 | −10.2 (−62.2 to 41.9) | .693 |
| Sitting time accumulated in bouts ≥30min (min/d) | 484.4±186.6 | 448.2±206.4 | 501.9±146.7 | 457.7±188.5 | −36.1±65.0 (−67.5 to −4.8) | .026 | −44.2±134.2 (−121.7 to 33.3) | .24 | −8.1 (−81.4 to 65.1) | .821 |
| Standing time (min/d) | 171.0±71.2 | 193.4±79.7 | 171.9±67.1 | 205.7±93.5 | 22.4±35.5 (5.4 to 39.6) | .013 | 33.8±59.3 (0.3 to 67.9) | .051 | −11.3 (−45.5 to 22.9) | .504 |
| Stepping time (min/d) | 66.8±48.8 | 74.5±57.8 | 67.5±38.1 | 74.1±45.3 | 7.8±19.2 (−1.5 to 17.0) | .096 | 6.6±36.9 (−14.6 to 27.9) | .516 | 1.2 (−19.3 to 21.7) | .907 |
| MVPA, ≥1952 cpm (min/d) | 8.8±11.2 | 7.7±11.4 | 7.2±6.3 | 10.9±11.0 | −0.6±10.9 (−6.4 to 5.3) | .842 | 4.1±9.7 (−1.9 to 10.3) | .161 | −3.8 (−11.8 to 4.1) | .332 |

NOTE. Values are mean ± SD or mean difference (95% CI). Sitting, prolonged sitting, standing, and stepping were derived from activPAL3 data; MVPA was derived from Actigraph data.
Abbreviation: cpm, counts per minute.
* Paired *t* test.
† Univariate analysis of variance.

Currently, the evidence for the effectiveness of behavior change interventions and self-management programs for increasing physical activity in people with stroke is limited.[29] Very few high-quality trials have been conducted to date, and there is little similarity in the content of the interventions delivered.[29] We chose to use a motivational interviewing intervention to target behavior change in this study. Although 1 previous study found this approach to be effective in increasing physical activity in people after stroke,[30] more high-quality trials are needed to evaluate the relative effectiveness of different behavior change interventions for people with stroke.

The barriers for people with stroke to exercise regularly at a moderate intensity are often insurmountable,[17,31] and efforts to address this have been largely ineffective.[32,33] Reducing daily sitting time may be a more achievable target with significant health benefits. We recently modeled the impact of replacing sitting with standing or stepping time or both, using accelerometer (activPAL3)-based measures of sitting time in a large sample of healthy adults.[34] Replacing 2h/d of sitting with either standing or stepping was associated with important reductions in cardiovascular disease risk.[34] Furthermore, experimental work in healthy adults has demonstrated that reductions in sitting time lead to clinically worthwhile reductions in cardiovascular disease risk factors (eg, improved glucose metabolism, reduced insulin resistance, decreased blood pressure), at least in the short term.[12,35] However, the longer-term benefits of changes in sitting time are not known.

## Study limitations

The lack of difference between intervention and control participants suggests the intervention requires development. We did not formally evaluate the degree to which our intervention adhered to motivational interviewing principles, or if there were any differences related to the 2 individual counselors delivering the intervention. This may also have contributed to the fact that the intervention expected to change behavior the most was not more effective. Furthermore, seasonal variations in habitual physical activity levels have been well documented[36] and may have played a role in this trial because data were collected across a 15-month time period. Although both modeling of epidemiologic data[13] and experimental work[12] suggest that changes in sitting time may lead to clinically meaningful reductions in cardiovascular disease risk, this requires testing in large-scale clinical trials. The study was not powered to detect a difference in safety measures between groups; therefore, we cannot exclude the possibility of modest harms. Future trials should carefully monitor fall rates and fear of falling. Accelerometers (eg, Actigraph) tend to underestimate step counts in people with slow walking speeds.[37] This may have affected the accuracy of the absolute values of physical activity in some of our participants, but it is not likely to have affected estimations of change over time. Finally, although all participants self-reported they had residual walking or balance deficits, 17% of participants recorded no symptoms on the National Health Institute of Stroke Severity Scale, indicating minimal to no disability.

## Conclusions

To our knowledge, this is the first clinical trial to demonstrate that it is possible for people with stroke to sit less each day. We have

**Table 5** Use of time data measured by the MARCA

| | Control Group | | Intervention Group | | Difference Between Groups in Change Scores | |
|---|---|---|---|---|---|---|
| Activity, min/d | Baseline | Postintervention | Baseline | Postintervention | Intervention−Control, Mean Difference | *P* |
| Total sitting time | 679±167 | 667±217 | 668±136 | 593±170 | 63 | .28 |
| Television | 221±157 | 183±133 | 303±183 | 257±120 | 8 | .13 |
| Passive transport | 36±41 | 62±58 | 50±64 | 42±49 | 34 | .10 |
| Reading | 45±61 | 75±69 | 47±78 | 51±92 | 26 | .42 |
| Sit and talk | 87±109 | 58±51 | 50±62 | 72±92 | 26 | .42 |

NOTE. Values are mean ± SD or as otherwise indicated.

demonstrated that the clinical trial protocol is both safe and feasible and leads to reductions in daily sitting time. However, the health benefits associated with sitting less each day remain unclear.

## Suppliers

a. PAL Technologies.
b. Microsoft Access 2010; Microsoft.
c. Actigraph.
d. Sensewear arm band; Temple Healthcare.

## Keywords

Exercise; Rehabilitation; Sedentary lifestyle; Stroke; Walking

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