Sitting and Activity Time in People With Stroke

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Background. Excessive sitting time is linked to cardiovascular disease morbidity. To date, no studies have accurately measured sitting time patterns in people with stroke.

Objective. The purpose of this study was to investigate the amount and pattern of accumulation of sitting time, physical activity, and use of time in people with stroke compared with age-matched healthy peers.

Design. This study used an observational design.

Methods. Sitting time (total and time accumulated in prolonged, unbroken bouts of ≥30 minutes) was measured with an activity monitor. Physical activity and daily energy expenditure were measured using an accelerometer and a multisensory array armband, respectively. All monitors had a 7-day wear protocol. Participants recalled 1 day of activity (during monitor wear time) using the Multimedia Activity Recall for Children and Adults.

Results. Sixty-three adults (40 with stroke and 23 age-matched healthy controls) participated. The participants (35% female, 65% male) had a mean age of 68.4 years (SD=10.0). Participants with stroke spent significantly more time sitting ($\overline{X}$=10.9 h/d, SD=2.0) compared with controls ($\overline{X}$=8.2 h/d, SD=2.0), with much of this sitting time prolonged (stroke group: $\overline{X}$=7.4 h/d, SD=2.8; control group: $\overline{X}$=3.7 h/d, SD=1.7). Participants with stroke accumulated most of their sitting time while watching television and in general quiet time, whereas control participants spent more time reading and on the computer. Physical activity and daily energy expenditure were lower in the stroke group compared with the control group.

Limitations. A sample of convenience was used to select participants for the stroke and control groups, which may reduce the generalizability of results.

Conclusions. Participants with stroke spent more time sitting and less time in activity than their age-matched peers. Further work is needed to determine whether reducing sitting time is feasible and leads to clinically important reductions in cardiovascular risk in this population.

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Stroke is the second highest cause of death and the third leading cause of disability worldwide.[1] People who have had a stroke are at high risk for further cardiovascular disease, with an estimated third of people who have had a stroke experiencing a recurrent stroke within 5 years,[2] with this figure increasing to 43% for people surviving 10 years or longer.[3] It is well known that people with stroke are less active than their healthy peers, accumulating, on average, half the daily step counts[4] and having fitness levels well below the average for their age.[5] It is well established that regular physical activity of at least moderate intensity reduces cardiovascular disease risk and risk of stroke, yet the barriers to achieving adequate physical activity levels for people with stroke are often insurmountable.[6]

There is rapidly accumulating evidence regarding the relationship of time spent in sedentary behaviors (sitting or lying down with low energy expenditure[7]) and poor health outcomes, and, in particular, an increase in cardiovascular disease risk.[8–10] For example, for every increase in television viewing time of 5 hours per week, there is an associated significant increase in the biomarkers for diabetes risk (fasting plasma glucose, insulin resistance, secretion and levels in women and insulin levels and 2-hour plasma glucose levels in men).[8] In a study of more than 222,000 Australian adults, participants who reported sitting for more than 11 hours per day were 1.4 times more likely to die (all-cause mortality) than those who reported sitting for less than 4 hours per day, regardless of the amount of time spent in physical activity.[11] It appears that the manner in which sitting time is accumulated is also important, with prolonged, uninterrupted bouts of sitting being particularly detrimental.[9,12] These associations are observed even after taking into account time spent in physical activity of at least moderate intensity.[7,8,13] In recognition of the health impacts of too much sitting, recommendations to reduce and break up prolonged sitting time, alongside existing physical activity guidelines, have now been introduced.[14–17]

One key reason for the improved understanding of the relationships of sedentary time with health is the advances in measurement methods for capturing this ubiquitous behavior. Activity monitors, such as the thigh-worn *activ*PAL (PAL Technologies Ltd, Glasgow, United Kingdom), provide us with the ability to accurately and objectively measure sitting time and activity levels in free-living situations.[18] Questionnaires and comprehensive recall methods, such as the Multimedia Activity Recall for Children and Adults (MARCA),[19] allow us to capture data on how people spend their day (use of time), which can provide valuable insight into the contexts in which sedentary behaviors occur. This information is important, as the interaction between activity and behavior is complex and multifactorial.[19] Gaining knowledge about use of time in people after stroke may provide valuable insights to aid in the planning of interventions to reduce sitting time.

A recently published systematic review of physical activity and sitting time of people with stroke[4] revealed no studies that specifically investigated sitting time in people with stroke. Therefore, the primary aim of this study was to describe and examine the amount of sitting time (including sitting time accumulated in long bouts) and the context of sitting time (use of time) in people with stroke compared with age-matched healthy peers. Given that the lack of physical activity is the second highest population-attributable risk factor for stroke[20] and that understanding of daily energy expenditure in people with stroke is limited, a secondary aim was to examine the time spent in different intensities of physical activity and daily energy expenditure in these 2 groups. As the MARCA has not been used previously in people with stroke, we also examined the test-retest reliability and validity of this tool. Specifically, our aim was to describe and examine differences between people with stroke and control participants in: (1) total daily sitting time, (2) daily sitting time accumulated in long bouts (≥30 minutes), (3) use of time, (4) time spent in different intensities of physical activity, and (5) daily energy expenditure.

Method

Study Design

This study used a prospective, cross-sectional observational design.

Participants

People with stroke were eligible to participate if they were at least 6 months poststroke (ischemic or hemorrhagic), had returned to living at home for at least 2 months since their most recent stroke, were able to walk independently around the house with or without walking aids, and had sufficient cognitive ability to provide informed consent. People with stroke who self-identified as having no deficits in lower limb strength or difficulties walking were excluded. Healthy control participants were eligible for inclusion if they had no history of stroke and were retired (working fewer than 2 days per week in voluntary or paid roles). Control participants were sex- and age-matched (±5 years) with the participants with stroke. People with stroke were recruited from community stroke exercise classes, outpatient physical therapist services, social media, and databases of people discharged from rehabilitation after stroke. Control participants were recruited by word of mouth, social media, and community exercise classes.

Forty people with stroke (mean age=67.2 years, SD=11.1) and 23 healthy adults (mean age=70.4 years, SD=7.8) were recruited. Table 1 presents the demographic characteristics of the sample.

Protocol

At baseline, all participants undertook a face-to-face assessment (either in their own home or at the University of South Australia) and 7 days of objective activity monitoring. The measurements taken at baseline included: height, weight, and waist circumference (measured using standard protocols and equipment)[21,22]; comfortable walking speed (measured using a stopwatch over the middle 5 m of a 9-m walkway)[23]; and cognitive ability (assessed with the Montreal Cognitive Assessment [MoCA]).[24] Additional information collected for the participants with stroke included: date of stroke, date of hospital discharge, usual walking aids, type of stroke (assessed with the Oxfordshire Stroke Classification),[25] and stroke severity (assessed with the National Institutes of Health Stroke Scale).[26] The activity monitors were attached and instructions were given during the face-to-face

Table 1.
Participant Demographic Characteristics[a]

Characteristic	Stroke Group (n=40)	Control Group (n=23)
Age (y), $\bar{X}$ (SD)	67.2 (11.1)	70.4 (7.8)
Sex, male:female	26:14	14:8
BMI (kg/m^2), $\bar{X}$ (SD)	29.1 (4.1)	26.1 (3.4)
Waist circumference (cm), $\bar{X}$ (SD)		
Male participants	103.7 (14.2)	95.2 (11.3)
Female participants	94.7 (12.6)	89.1 (14.6)
Walking speed (m/s), $\bar{X}$ (SD) [range]	0.8 (0.4) [0.1–1.6]	1.4 (0.2) [0.94–1.78]
Walking aids, n (%)		
None	26 (65)	
AFO only	2 (5)	
AFO+stick	4 (10)	
Stick only	6 (15)	
Frame only	2 (5)	
Type of stroke, n (%)		
TACI	7 (17.5)	
PACI	15 (37.5)	
LACI	6 (15.0)	
POCI	1 (2.5)	
Hemorrhage	9 (22.5)	
Unknown	2 (5.0)	
Severity of stroke (NIHSS), n (%)		
No symptoms (score 0)	6 (15)	
Mild (score 1–4)	34 (85)	
Time since stroke (y), $\bar{X}$ (SD) [range]	4.4 (10) [0.2–64.0][b]	

[a] BMI=body mass index, AFO=ankle-foot orthosis, TACI=total anterior circulation infarct, PACI=partial anterior circulation infarct, LACI=lacunar infarct, POCI=posterior circulation infarct.
[b] One participant had a childhood stroke.

assessment. All participants were asked to keep a daily diary of sleep and wake times and times when the monitors were removed.

Outcome Measures

There is no single objective activity monitor or instrument that best captures all aspects of sitting time, physical activity, and energy expenditure. Therefore, we chose the best available instrument to measure each of the following variables.

Sitting time. Sitting time was measured using the *activ*PAL3 activity monitor (PAL Technologies Ltd). This small unit (measuring 5.0 × 3.5 × 0.7 cm and weighing 20 g) contains a triaxial accelerometer and inclinometer and is worn attached to the anterior thigh. It provides date and time-stamped information on sitting, standing, and stepping and is able to record and store data for 14 days of continuous monitoring. Unlike monitors that infer sedentary time from lack of movement or low energy expenditure, the *activ*PAL directly measures posture. It has 100% accuracy in classifying sitting and standing positions in older people, including people with stroke, compared with direct observation.[27] The monitor was waterproofed, attached to the nonparetic thigh (or the right leg of control participants), and worn continuously (24 hours per day) for 7 days.

Physical activity. Physical activity was measured using the ActiGraph GT3X+ triaxial accelerometer (ActiGraph, Pensacola, Florida), worn on an elasticized waistband in the midaxillary line above the nonparetic hip (people with stroke) or right hip (control participants). The accelerometer was worn for 7 days, 24 hours a day, and was removed only for showering and water-based activities. The GT3X+ measures acceleration in 3 individual planes (vertical, front to back, and side to side) and provides activity counts as a composite vector of these 3 axes.[28] This device has been shown to discriminate well among different movement speeds, ranging from slow walking (0.89 m/s) to moderate running (2.7 m/s).[29] Although the GT3X+ has been shown to be an accurate tool to estimate free-living physical activity,[30] it has been reported to underestimate energy expenditure during slow walking and to overestimate energy expenditure during fast walking.[31] Therefore, this device was not used to estimate daily energy expenditure in this study.

Daily energy expenditure. Daily energy expenditure was measured using a SenseWear multisensory array armband (BodyMedia Inc, Pittsburgh, Pennsylvania) around the upper arm of the nonparetic arm (or left arm of control participants). The SenseWear armband uses data on movement (triaxial accelerometer), heat flux, skin temperature, and galvanic skin response collected in 1-minute epochs to estimate energy expenditure via in-built algorithms. Estimates of daily energy expenditure from this device have a strong agreement (r=.85, P=.004) with doubly labeled water estimates of energy expenditure (criterion tool) in people with stroke.[32]

Use of time. Use of time was measured using the Multimedia Activity Recall for Children and Adolescents (MARCA),[19] which was administered via telephone interview. The MARCA is a computerized tool that asks people to recall their activities of the previous day between midnight and midnight. It uses mealtimes as anchor points, and for each period of activity (minimum of 5 minutes' duration), participants choose from 520 different activities. The 520 MARCA activities are aggregated into "superdomains," such as "screen time" and "chores," which are then hierarchically subdivided into "macrodomains," such as "indoor chores" and "outdoor chores." The adult version of the tool has high test-retest reliability (rho>.99) and convergent validity with accelerometer measures of activity (rho=.72)[19] and with doubly labeled water (rho=.40).[33] Test-retest reliability was assessed by asking participants to complete duplicate recalls of the same day with a minimum 4-hour break between first and second recalls. MARCA interviews took between 15 and 20 minutes to complete.

Data Processing

Sitting time *activ*PAL3 data were downloaded via the manufacturer's software (*activ*PAL3, version 7.1.18), with event files and 15-second epoch files saved as Excel (Microsoft Corp, Redmond, Washington) spreadsheets. Sleep and wake times were entered into a Microsoft Access database, with estimated sleep and wake times (from the event files) used if diary data were missing. A custom-built SAS program (SAS Institute Inc, Cary, North Carolina) linked participant diary data with *activ*PAL event file data to extract data relating to waking hours only. Periods of wake time were confirmed by examination of heat maps of wake time *activ*PAL data for each participant on each monitored day. Where the reported wake periods appeared incorrect—for example, where prolonged periods of lying or sitting occurred at the beginning or end of a day—they were adjusted by identifying sleep and wake periods from the raw *activ*PAL event file data, amending the sleep and wake time diaries, and reprocessing these data. These daily sleep and wake times also were applied to the ActiGraph and SenseWear armband data.

Wear time validation (ActiGraph and SenseWear). As the ActiGraph and SenseWear armbands had to be removed for any water-based activities, their removal increased the risk of participants forgetting to put the monitors back on, making identification of wear time important. The SenseWear armband collects data only when the sensors are in contact with the skin, which allows periods of not wearing the armband to be easily identified. We checked the participants' sleep and wake logs and found that participants always reported identical removal periods for both monitors. Therefore, we removed all SenseWear-detected periods of nonwear time from the ActiGraph data. Data from participants with less than 4 hours of wear time per day were excluded from further analysis.

Physical activity. ActiGraph data were processed using ActiLife software, version 6.3.2 (ActiGraph). Custom-made filters were used to identify wake time periods for each day of data for each participant. Cutoff points for classifying intensity of physical activity were based on Freedson and colleagues' equations of light (100–1,951 counts per minute [cpm]), moderate (1,952–5,724 cpm), and vigorous (≥5,725 cpm) intensity,[34] with moderate-to-vigorous physical activity (MVPA) categorized as ≥1,952 cpm. This approach is consistent with the majority of studies of physical activity in older adults.[35] SenseWear data were processed using SenseWear Professional software, version 8.0 (BodyMedia Inc), with custom-made filters for daily wake periods.

MARCA. The MARCA data were examined for periods of nonrecall. Where participants had periods of not being able to recall activities for more than 2 hours in total, their data were removed from further analyses.

Data Analysis

Between-group differences were assessed using independent *t* tests, or Mann-Whitney *U* tests where data were not normally distributed. Sequential Bonferroni adjustments were applied for all comparisons using the objective activity monitoring, and separately for MARCA-derived variables. Data are expressed as means and standard deviations unless otherwise specified. To further examine patterns of accumulation of sitting time, we plotted the cumulative proportion of total sitting time (y-axis) against sitting bout length of increasing duration (x-axis) separately for the stroke and control groups. From these data, we calculated the cumulative proportion of sitting time accrued in prolonged, unbroken bouts using cutoff points of 30 minutes and 60 minutes.

Test-retest reliability of the MARCA for people with stroke was assessed using intraclass correlation coefficients (ICCs) for reported minutes spent in the superdomains of chores, quiet time, screen time, and total sitting time. Validity of the MARCA was assessed using ICCs for MARCA and *activ*PAL estimates of total sitting time and for MARCA and SenseWear armband estimates of total daily energy expenditure.

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Results

There was 100% adherence to monitor wear, with the exception of one participant (control group) who did not wear the *activ*PAL due to equipment being unavailable.

Sitting and Activity Time (*activ*PAL3 Activity Monitor)

Table 2 summarizes sitting time and activity data from the objective activity monitors. During waking hours, participants with stroke spent 2.7 hours (95% confidence interval [CI]=1.6, 3.7) more sitting compared with the control group. People with stroke accumulated their sitting time in longer bouts. As illustrated in Figure 1, in the stroke group, 33.2% and 59.6% of sitting time was accumulated in bouts of <30 and <60 minutes, respectively. These figures were 41.3% and 65.8%, respectively, for the control group. Participants with stroke also spent significantly less time standing (−2.5 hours; 95% CI=−3.4, −1.7) and stepping (−1.0 hours; 95% CI=−1.4, −0.6) compared with controls.

Table 2.
Sitting Time, Physical Activity, and Daily Energy Expenditure Data Obtained From Objective Activity Monitoring[a]

Variable	Stroke Group X̄ (SD) [Range]	Control Group X̄ (SD) [Range]	Mean Difference (95% CI) (Stroke Group − Control Group)	*P* Value (Independent *t* Test)
***activ*PAL-derived variables (stroke group: n=39; control group: n=22)**				
Wake time (h/d)	14.2 (1.3) [11.6 to 17.8]	15.5 (0.8) [13.9 to 17.4]	−0.89 (−1.5 to −2.4)	.008[b]
Total sitting time (h/d)	10.9 (2.0) [6.9 to 15.3]	8.2 (2.0) [3.9 to 12.1]	2.7 (1.6 to 3.7)	<.001[b]
Sitting time accumulated in bouts ≥30 min (h/d)	7.4 (2.8) [1.3 to 13.0]	3.7 (1.7) [1.8 to 8.2]	3.7 (2.3 to 5.0)	<.001[b]
% wake hours sitting	74.8 (13.3) [47.4 to 97.0]	52.8 (12.3) [25.2 to 74.8]	21.7 (14.8 to 28.6)	<.001[b]
% waking hours sitting in bouts ≥30 min	51.6 (18.3) [19.0 to 87.1]	24.0 (10.9) [10.9 to 54.4]	26.7 (17.6 to 35.7)	<.001[b]
Standing time (h/d)	2.6 (1.5) [0.4 to 6.3]	5.2 (1.7) [2.5 to 9.6]	−2.5 (−3.4 to −1.7)	<.001[b]
Stepping time (h/d)	1.1 (0.8) [0.02 to 2.6]	2.2 (0.8) [1.0 to 3.5]	−1.0 (−1.4 to −0.6)	<.001[b]
Sit-to-stand transition	41.2 (18.1) [15.0 to 96.9]	47.8 (15.6) [24.7 to 96.5]	−6.6 (−16.0 to 2.7)	.162
Steps	2,411 (1,835) [24 to 8,252]	5,314 (2,100) [2,069 to 9,278]	−2,903 (−3,949 to −1,857)	<.001
ActiGraph (GT3x+)–derived variables (stroke group: n=37; control group: n=21)				
LPA (100–1,951 cpm), min/d	206.0 (93.8) [44.3 to 420.0]	361.5 (86.8) [199.0 to 523.5]	−155.5 (−205.6 to −105.5)	<.001[b]
% waking hours in LPA	23.4 (11.2) [5.4 to 47.4]	39.1 (9.4) [22.0 to 56.6]	−15.7 (−21.7 to −9.8)	<.001[b]
MVPA (≥1,952 cpm), min/d	4.9 (5.8) [0 to 18]	38.0 (31.0) [4.3 to 110.0]	−33.1 (−43.6 to −22.7)	<.001[b,c]
% waking hours in MVPA	0.52 (0.65) [0 to 2.3]	4.2 (3.5) [0.48 to 12.1]	−3.6 (−4.8 to −2.4)	<.001[b,c]
SenseWear armband–derived variables (stroke group: n=40; control group: n=22)				
Total daily energy expenditure (kJ/d)	7,210 (2,399)	8,315 (1,677)	−1,104 (−2,258 to 49)	.060

[a] CI=confidence interval, LPA=light physical activity, MVPA=moderate-to-vigorous physical activity.
[b] *P* value remained significant after sequential Bonferroni adjustments.
[c] Equal variances not assumed; visual inspection shows stroke data for MVPA highly skewed. Mann-Whitney *U* test also significant at *P*<.001.

Physical Activity (GT3X+ Activity Monitor)

A total of 37 people with stroke and 21 control participants (94%) had valid GT3X+ activity monitor data. Participants with stroke spent significantly less time in both light-intensity physical activity (mean difference=−155.5 min/d; 95% CI=−205.6, −105.5) and MVPA (mean difference=−33.1 min/d; 95% CI=−43.6, −22.7) (Tab. 2). A total of 15 participants with stroke (41%) recorded an average of less than 1 minute of MVPA per day. The lowest daily MVPA in the control group was 4.3 minutes (n=2, 10%), with all other healthy participants recording at least 8.0 minutes of MVPA per day.

Daily Energy Expenditure (SenseWear Armband)

Total daily energy expenditure was higher in the control group (X̄=8,315 kJ, SD=1,677) compared with the stroke group (X̄=7,210 kJ, SD=2,399), but this difference was not statistically significant (Tab. 2).

Use of Time (MARCA)

Complete MARCA profiles were available for 36 participants with stroke and 20 controls (89%), and 30 participants with stroke completed duplicate recalls. Test-retest reliability was high, with ICC values between .834 (95% CI=.681, .918) and .946 (95% CI=.890, .974) for the superdomains. High levels of agreement also were found between MARCA and *activ*PAL estimates of total sitting time (ICC=.666; 95% CI=.382, .835) and between MARCA and SenseWear estimates of total daily energy expenditure (ICC=.617; 95% CI=.323, .802). Table 3 and Figure 2 summarize the between-group differences in participants' use of time.

Participants with stroke spent significantly more time in sitting, in quiet time (not related to reading), and in the self-care tasks of showering and grooming. Control participants spent significantly more time each day doing chores.

Discussion

Our study showed that people with stroke spent significantly more time sitting during the day, particularly in prolonged bouts, compared with age-matched healthy participants. People with stroke also spent significantly less waking time standing, walking, and engaging in all intensities of physical activity (light, moderate, and vigorous) than controls. Given the well-established effects of physical activity and sitting time on cardiovascular disease and stroke risk,[20,36] these data should serve as a call to action for clinicians and researchers to find ways to enable people with stroke to increase their physical activity and reduce their sitting time.

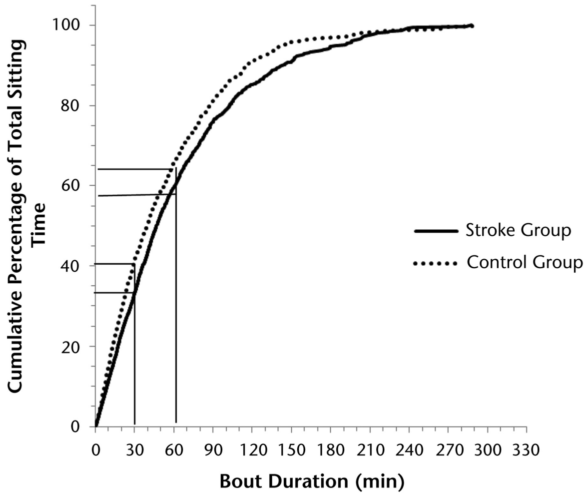

Figure 1.
A sedentary accumulation graph depicting the cumulative percentage of sitting time in relation to bout duration. The horizontal lines indicate the percentage of total sitting time accumulated in bouts of less than 30 minutes and 60 minutes (common cutoffs). For stroke, this means that ≈67% and 40% of their sitting time was accumulated in bouts ≥30 and ≥60 minutes in duration, respectively, in comparison with controls (≈59% and 34%, respectively).

Our findings are consistent with previous studies with regard to lower number of transitions per day in people with stroke versus controls and lower daily step counts.[4,37] We have added knowledge to this field by utilizing high-precision instruments to provide a detailed picture of sitting time and activity patterns in this population. Only one previous study has reported objectively measured sitting time in people with stroke.[37] That observational study, involving 42 people with stroke who were able to walk independently and 21 age-matched healthy controls, used the Intelligent Device for Energy Expenditure and Activity monitor to measure the time participants spent either sitting or lying down during waking hours over 2 days, 1 week apart. The monitors were put on only after participants were up and dressed for the day and were taken off just prior to bedtime. The study by Alzahrani et al[37] showed that healthy control participants spent a similar amount of time sitting (around 7 hours) compared with people with stroke but over a longer monitored period (average of 11 hours versus 13 hours). In contrast, in the current study, we measured sitting time for all participants continuously over a 7-day period, which provides a more accurate reflection of free-living, habitual activity. Furthermore, to our knowledge, our study is the first to show that people with stroke accumulate their sitting time in longer bouts each day compared with healthy controls. The proportion of total sitting time accumulated in bouts of 30 minutes or more for people with stroke in this study (70%) is similar to that found in a cohort of older adults (mean age=84 years, range=61–95) living in aged-care facilities (73%).[38] It is important to note that both our study and the study by Alzahrani et al[37] included people with only mild stroke-related disability and relatively fast average walking speed.[39] People with greater disability and slower walking speeds are likely to spend even more time sitting each day.

We found that people with stroke participated in significantly less standing, stepping, and physical activity at all intensities than age-matched controls. Previous studies have used objective measures of physical activity intensity, including measuring heart rate[40] and quantifying intensity based on step cadence,[41,42] in this population. In this study, we used validated cutoff points for accelerometer counts to accurately measure the time that participants spent in light, moderate, or vigorous physical activity[34,35] and found that people with stroke accumulated very little time in MVPA. The most appropriate cutoff point for use in estimating time spent in MVPA is a fraught issue. We chose to use a cutoff point of ≥1,952, as it is the most commonly used cutoff point for older adults.[35] Other cutoff points developed specifically for older adults[43] have been found to overestimate time spent in MVPA.[35] It may be that individualized cutoff points are the most accurate method of classifying activity levels,[35] particular in populations such as people with stroke where both age and degree of physical ability can vary greatly. However, the use of individualized cutoff points was not feasible in our study.

Energy expenditure in people with stroke is not well understood, with only one other study reporting average daily energy expenditure in this group.[44] Similar to our results, the study by Moore et al[44] also demonstrated daily energy expenditure in people with stroke to be lower than that of age-matched healthy adults. Several studies have compared the energy costs of standing and walking for people with stroke with those for healthy control participants[45–47] and have generally found them to be higher in people with stroke.[48] The magnitude of the increased energy cost of standing and walking is likely to be dependent, at least to some extent, on the degree of lower limb motor impairment. As our study included participants with mostly mild stroke, energy costs of standing and walking may have been similar across participant groups. Therefore, the lower daily energy expenditure in the people with stroke is likely a reflection of the lower amount of daily physical activity undertaken. More high-quality data regarding the energy costs of standing, walking, and activities of daily living in people with differing degrees of motor impairment after stroke are needed to further our understanding of the interplay between physical activity and energy expenditure in people with stroke.

Understanding the types of activities that people with stroke engage in each day can help us determine potential drivers for sitting time and physical activity. The use of the MARCA in our study allowed us to describe daily activities of people with stroke in detail. People with stroke

Table 3.
Use of Time Summary Data

Superdomain	Activity	Stroke Group (n=36), min/d, $\overline{X}$ (SD)	Control Group (n=20), min/d, $\overline{X}$ (SD)	*P* Value (Mann-Whitney *U* Test)[a]
Total sitting time		729 (143)	602 (153)	.006
Screen time		269 (173)	191 (79)	.163
	Television	269 (174)	174 (85)	.052
	Videogames	0.42 (2.5)	14.8 (38.6)	.081
Quiet time		161 (127)	107 (74)	.191
	Reading	40 (53)	72 (73)	.058
	Other (listening to music, sitting quietly, meditation)	122 (114)	35 (45)	.002
Sleep		514 (129)	469 (82)	.212
Social		91 (96)	76 (56)	.959
	Communication	86 (97)	62 (55)	.577
	Socializing	5 (14)	12 (23)	.130
Self-care		129 (45)	130 (34)	.644
	Eating	67 (30)	80 (16)	.028
	Grooming/showering	63 (28)	50 (24)	.060
Work/study		80 (120)	122 (117)	.043
	Work	6 (19)	23 (56)	.210
	Study	4 (10)	6 (20)	.904
	Computer	70 (120)	93 (101)	.058
Chores		81 (76)	219 (117)	**<.001**
	Indoor chores (eg, cooking, cleaning, laundry, shopping)	13 (27)	38 (70)	.031
	Outdoor chores (eg, gardening, mowing lawns, fixing cars)	6 (24)	54 (94)	**<.001**

[a] Bold type indicates difference remained significant after sequential Bonferroni adjustment.

spent more time in general quiet time and watching television and much less time in more cognitively demanding tasks such as work, study, and reading. Furthermore, people with stroke spent very little time engaged in household chores. We also have shown that the MARCA is a reliable tool to use with people after stroke, even those with mild cognitive impairment. This tool has great potential for use in exploring use of time in larger samples of people with stroke with varying degrees of ability and to measure the impact of physical activity interventions.

Strengths and Limitations

This study has several methodological strengths. The main strength lies in the use of 3 objective activity monitors, which allowed us to use the most accurate measure available for each variable of interest for the same monitored period. Although the wearing of 3 concurrent activity monitors for a 7-day monitoring period may seem burdensome, adherence was high, with the majority of participants achieving valid data for all monitors. This finding suggests that the measurement protocol used in this study is feasible in this population. We recommend that future studies use the most accurate and valid measurement tool for the primary variable of interest.

The inclusion of a contemporaneous healthy control group is a further strength of the study. The amount of time spent in physical activity in our control group was similar to that reported in large-scale studies of healthy adults (which also used accelerometry-derived estimates of physical activity).[49] For example, data from the 2003–2004 US National Health and Nutrition Examination Survey (NHANES) from more than 6,000 participants aged over 20 years showed that MVPA accounted for 5% of participants' waking hours (versus 4% in the current study) and that light physical activity accounted for between 27% and 44% of participants' waking hours (versus 39% in the current study).[49] However, it must be acknowledged that the participants in our study were older adults. Comparing the healthy adults in the current study (mean age=70 years) with a sample of Canadian healthy adults aged 60 to 79 years (n=901),[50] the participants in our sample engaged in more light physical activity (39% versus 25% of waking hours) and MVPA (4% versus 1%–2% of waking hours). Therefore, it is a limitation of the current study that our

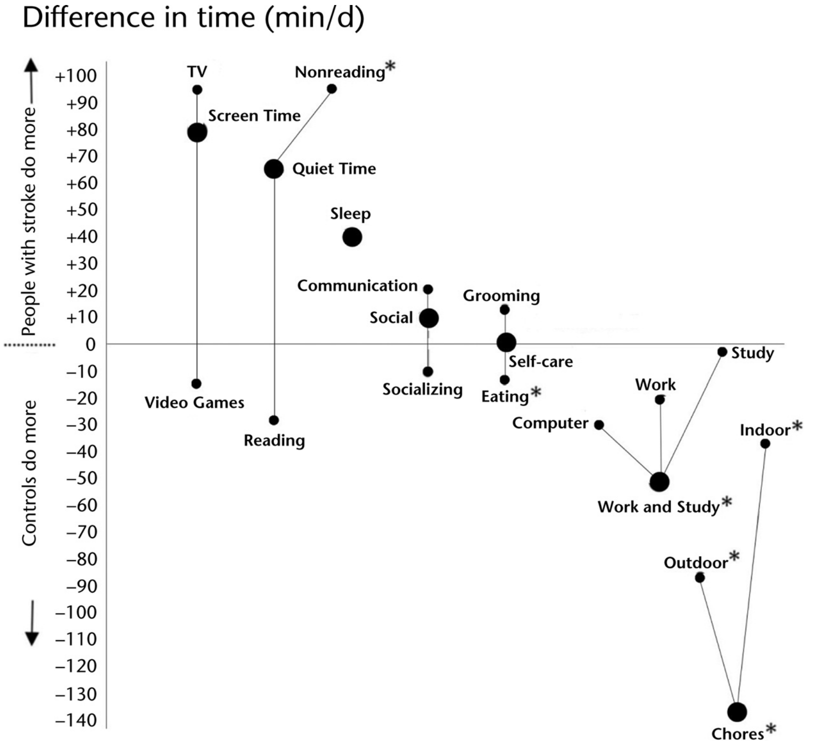

Figure 2.
Visual representation of control group and stroke group participants' use of time (min/d) as measured with the Multimedia Activity Recall for Children and Adults (MARCA). Large dots represent superdomains, and smaller dots represent macrodomains. Asterisks indicate statistically significant differences.

healthy control group was perhaps more active than average older adults.

Although MARCA data are self-reported and may suffer from problems of recall and social desirability bias, the MARCA data in this study showed good reliability in 30 participants who completed duplicate recalls of the same day. We also have confirmed that the MARCA is a valid method of estimating total daily sitting time and total daily energy expenditure in people with stroke.

Given the demonstrated associations between total sedentary time and time spent in prolonged sitting without breaks with chronic disease and mortality, the findings from this study are of concern for people living with stroke. The high degree of sitting time found for people with stroke in this study matches the highest quartile of sitting and cardiovascular disease risk reported in epidemiological studies.[51–53] We currently do not know whether it is possible to reduce sitting time in people with stroke or whether reducing sitting time will reduce cardiovascular disease risk. However, given that people with stroke find it extremely difficult to engage in physical activity of at least moderate intensity,[54] clinicians should be encouraged to find ways for their clients to replace some sitting time with incidental, light-intensity activity each day.

Our study provides valuable, high-quality, accurate data on daily sitting time, physical activity, and energy expenditure in people living with stroke in the community. It is also, to our knowledge, the first study to report detailed use-of-time data for this group. The findings present novel data that will aid in the development of directed interventions aimed at reducing sitting time in this population.

Dr English, Associate Professor Coates, Professor Olds, and Professor Bernhardt provided concept/idea/research design. All authors provided input in the manuscript preparation and consultation (including review of manuscript before submission). Dr English provided data collection and project management. Dr English, Dr Healy, Dr Lewis, and Professor Olds provided data analysis. Dr English, Professor Bernhardt, Professor Olds, and Associate Professor Coates provided fund procurement. Professor Olds provided facilities/equipment and administrative work.

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