

# Duration of physical activity is normal but frequency is reduced after stroke: an observational study

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**Question:** What is the free-living physical activity of community-dwelling people with stroke compared with that of age-matched healthy controls? **Design:** A cross-sectional observational study. **Participants:** 42 people with stroke and 21 age-matched healthy controls aged 52 to 87 years living in Sydney, Australia. **Outcome measures:** Free-living physical activity was measured using the Intelligent Device for Energy Expenditure and Activity (IDEEA) and reported as duration (time on feet in min) and frequency (activity counts). **Results:** People with stroke spent 79 (95% CI 20 to 138) fewer min on their feet and performed 5308 (95% CI 3171 to 7445) fewer activity counts than healthy controls. The observation period of the free-living physical activity of stroke survivors was significantly less than that of the healthy controls. Data adjusted to a fixed observation period (12 hr) showed no relative difference in time on feet between the groups (mean difference 36 min, 95% CI -27 to 99) but that people after stroke still had relatively fewer activity counts than healthy controls (mean difference 4062 counts, 95% CI 1787 to 6337). **Conclusions:** The reduction in physical activity after stroke is not primarily because of a decrease in the time spent being active but rather a decrease in frequency of activity during that time. Future research into physical activity after stroke needs to consider energy expenditure because stroke survivors exhibit a reduced frequency of physical activity due to the nature of their impairments. [Alzahrani MA, Ada L, Dean CM (2011) Duration of physical activity is normal but frequency is reduced after stroke: an observational study. *Journal of Physiotherapy* 57: 47–51]

**Key words:** Motor activity, Ambulatory monitoring, Stroke, Aged, Time, Physiotherapy

## Introduction

The importance of physical activity to health is well established. Regular physical activity is critical for decreasing and maintaining body weight, blood pressure, total blood cholesterol, serum triglycerides, and low-density lipoprotein cholesterol (Franklin and Sanders 2000). In addition, it can play an antithrombotic role by reducing blood viscosity (Koenig et al 1997), fibrinogen levels (Ernst 1993), and platelet aggregability (Rauramaa et al 1986). There is evidence from a meta-analysis of cohort studies that physical activity has a neuroprotective effect against stroke and may decrease stroke incidence (Lee et al 2003, Wendel-Vos et al 2004) and the incidence of recurrent strokes (Gordon et al 2004).

There is growing evidence that the free-living physical activity of people with stroke is less than that of healthy controls. Studies have used different devices to measure activity including step activity monitors (Manns et al 2009, Michael and Macko 2007, Michael et al 2005, Rand et al 2009) and accelerometers (Hale et al 2008). Activity levels for community-dwelling people with stroke as low as 1389 steps/day have been reported (Michael et al 2007). Similarly, Manns and colleagues (2009) reported that the number of steps carried out per day by people with stroke (7379 steps/day, SD 3107) was only half that of healthy controls (14 730 steps/day, SD 4522). The studies to date, however, have reported a single point estimate of physical activity (eg, steps or activity counts) and most have had small samples, ie, less than 20.

There are now devices that provide more detailed information about the nature of physical activity. The

Intelligent Device for Energy Expenditure and Activity (IDEEA) is one such device. It estimates duration and frequency of activity as well as distinguishing the position of the body in which the activity is undertaken, eg, sitting, lying, standing, walking. In one study using this device, Sakamoto and colleagues (2008) found that nine community-dwelling stroke survivors stood for less time than healthy controls but lay, sat, and walked for about the same amount of time. Our study extends this work by using the IDEEA to examine the free-living physical activity of a larger sample of community-dwelling people with stroke compared with that of age-matched healthy controls. The specific research questions for this study were:

1. What is the duration and frequency of physical activity in community-dwelling people after stroke compared with age-matched healthy controls?
2. Is there any difference between the groups in the body position where most physical activity is carried out?

## Method

### Design

A cross-sectional observational study examining the free-living physical activity of ambulatory community-dwelling people with stroke compared with that of age-matched healthy controls was conducted in Sydney, Australia. Duration and frequency of physical activity was collected over two days. Each participant was randomly allocated a day of the week and wore the activity monitor on this day and again a week later on the same day. The days for measurement of free-living physical activity were counterbalanced across the week so that there were the same number of participants represented on each day of the

**Table 1.** Characteristics of participants.

Characteristics	People with stroke (n = 42)	Healthy elderly (n = 21)
Age (yr), mean (SD)	70 (10)	69 (7)
Gender, number male (%)	29 (69)	11 (52)
Weight (kg), mean (SD)	73 (12)	78 (13)
Height (m), mean (SD)	1.67 (0.08)	1.58 (0.19)
BMI (kg/m <sup>2</sup> ), mean (SD)	26.4 (4.3)	27.5 (3.9)
Side of hemiplegia, n right side (%)	23 (55)	n/a
Time since stroke (yr), mean (SD)	2.8 (1.4)	n/a
Walking ability		
10 m Walk test (m/s), mean (SD)	0.80 (0.34)	n/a
6 min Walk test (m), mean (SD)	317 (115)	n/a

week. Data were collected from 30 min after dressing until 30 min prior to undressing. Participants were instructed to carry out their routine activities.

### Participants

Stroke survivors and healthy controls who were living in the community were recruited using advertisements in the local community, including stroke clubs. People with stroke were included in the study if they were over 50 years old, within 1 to 5 years of their first stroke, able to walk 10 m independently, and retired from full-time employment. Healthy controls were included if they were over 50 years old, retired from full-time employment, and had no health problem that interfered with their ability to walk. They were excluded if they could not speak English or if they were unable to follow instructions.

### Measurement of physical activity

Free-living physical activity was collected using the Intelligent Device for Energy Expenditure and Activity<sup>a</sup> consisting of a recorder and five sets of sensors. The sets of sensors are attached to the front of the chest, the front of each thigh, and underneath each foot using medical tape, and measure angles of body segments and acceleration in two orthogonal directions. The recorder is light (58 g), can operate at 32 MHz for over 48 hr, and is clipped to the belt or waist of the pants. Body positions (lying, reclining, sitting, standing, leaning), transitions (lie to sit, sit to lie, recline to sit, sit to recline, recline to stand, stand to recline, sit to stand, stand to sit), and gait (walking, ascending and descending stairs, running, and jumping on both legs) are measured. It has been found to be > 98% accurate when measuring duration, frequency, body position, and intensity of a variety of physical activities in normal adults (Zhang et al 2003), and reliable and valid for measuring time spent walking in people after stroke (Saremi et al 2006). We also compared the IDEEA with direct observation in three people after stroke with varying walking abilities. There are two algorithms available for use, one of which is more sensitive to pathological movement. When using this algorithm, we found that the accuracy of duration of physical activity was 99% and the accuracy of frequency of physical activity was 94%.

An investigator visited participants' homes and calibrated the device. The recording of physical activity was then begun, with the investigator returning to turn the device off and check the data at the end of the day. The intraclass

correlation coefficients (ICC<sub>3,1</sub>) for time on feet and activity counts between the 2 days of measurement across 2 weeks for people with stroke were 0.69 and 0.80, respectively, and for healthy controls were 0.68 and 0.50, respectively. Given that there was some variability across the two days of measurement, physical activity data were averaged across the two days. Free-living physical activity was reported as duration (time on feet and time not on feet) and frequency of activity (activity counts) carried out per day (Berlin et al 2006). 'Time on feet' was measured in minutes and comprised the time spent walking, going up and down stairs, standing, and in sit to stand transitions. 'Time not on feet' comprised time spent sitting, reclining, and lying down. 'Activity counts' comprised the number of steps walked, stairs ascended and descended, and number of sit to stand transitions.

### Statistical analyses

Data were obtained from 42 people with stroke and 21 apparently healthy controls, which meant that each day of the week was represented by data from 6 stroke survivors and 3 healthy controls. Data were tested for normal distribution. The Shapiro-Wilk normality test indicated that the number of transitions, the number of stairs, and the time spent lying down, reclining, making transitions, and ascending and descending stairs were not normally distributed in both groups. The number of steps and activity counts were not normally distributed in people with stroke. However, independent t-tests and Mann-Whitney tests examining the difference between groups yielded the same results. Therefore, we present the size of the differences between groups as mean difference (95% CI) and the statistical significance from independent t-tests. In addition, because of differences in observation time between the groups, a *post-hoc* analysis of the data adjusted to an observation period of 12 hours was undertaken.

## Results

### Characteristics of participants

Forty-two community-dwelling people with stroke who were aged 70 years old (SD 10) and 13 (31%) of whom were women participated. They were on average almost 3 years from the onset of stroke and approximately half of them were right hemiplegics. Twenty-one age-matched healthy controls who were aged 69 years old (SD 7) and 10 (48%) of whom were women also participated. The mean BMI of stroke survivors (26.4 kg/m<sup>2</sup>, SD 4.3) was slightly less than

**Table 2.** Mean (SD) values of free-living physical activity of people with stroke and healthy controls and mean (95% CI) difference between groups.

Free-living physical activity	Groups		Difference between groups
	Stroke (n = 42)	Healthy controls (n = 21)	Stroke minus healthy controls
Time on feet ( <i>min</i> )	230 (115)	309 (103)	-79 (-138 to -20)
Walking	101 (59)	109 (34)	-8 (-36 to 20)
Standing	126 (64)	185 (72)	-59 (-95 to -23)
Stairs	2 (4)	14 (9)	-12 (-15 to -9)
Transitions	1 (1)	2 (2)	-1 (-2 to 0)
Time not on feet ( <i>min</i> )	418 (101)	454 (96)	-36 (-89 to 17)
Sitting	346 (101)	380 (100)	-34 (-88 to 20)
Reclining	34 (32)	29 (24)	5 (-11 to 21)
Lying	38 (48)	45 (53)	-7 (-34 to 20)
Activity counts ( <i>n</i> )	5656 (4091)	10964 (3804)	-5308 (-7445 to -3171)
Walking	5475 (3999)	9501 (3201)	-4026 (-6033 to -2019)
Stairs	124 (303)	1354 (912)	-1230 (-1539 to -921)
Transitions	57 (43)	109 (91)	-52 (-86 to -18)

**Table 3** Mean (SD) values of free-living physical activity of people with stroke and healthy controls and mean (95% CI) difference between groups after normalising the observational period to 12 hr.

Free-living physical activity	Groups		Difference between groups
	Stroke (n = 42)	Healthy controls (n = 21)	Stroke minus healthy controls
Time on feet ( <i>min</i> )	256 (128)	292 (97)	-36 (-99 to 27)
Walking	112 (66)	103 (32)	9 (-22 to 40)
Standing	140 (71)	175 (68)	-35 (-72 to 2)
Stairs	2 (4)	13 (8)	-11 (-14 to -8)
Transitions	1 (1)	2 (2)	-1 (-2 to -0.3)
Time not on feet ( <i>min</i> )	464 (112)	428 (91)	36 (-20 to 92)
Sitting	384 (112)	359 (94)	25 (-32 to 82)
Reclining	38 (36)	27 (23)	11 (-6 to 28)
Lying	42 (53)	42 (50)	0 (-28 to 28)
Activity counts ( <i>n</i> )	6284 (4546)	10346 (3590)	-4062 (-6337 to -1787)
Walking	6083 (4443)	8966 (3021)	-2883 (-5038 to -728)
Stairs	138 (337)	1278 (861)	-1140 (-1442 to -838)
Transitions	63 (48)	103 (86)	-40 (-74 to -6)

that of healthy controls (27.5 kg/m<sup>2</sup>, SD 3.9). Participants' characteristics are presented in Table 1.

### Duration of physical activity

People with stroke spent 79 min (95% CI 20 to 138) less time on their feet than healthy controls (Table 2). They spent significantly less time in standing, ascending and descending stairs, and transitions than healthy controls but not walking. On average, the observation period of the free-living physical activity of stroke survivors (10.8 hr) was significantly ( $p < 0.001$ ) less than that of the healthy controls (12.7 hr). After adjusting the observation period to 12 hr, there was no significant difference between groups in terms of time on feet (mean difference 36 min, 95% CI -27 to 99) (Table 3).

People with stroke spent 36 min (95% CI -17 to 89) less time not on their feet than healthy controls, which was not statistically significant (Table 2). They spent approximately the same time in sitting, reclining, or lying as healthy controls. After adjusting the observation period to 12 hr, the difference remained statistically non-significant (Table 3).

### Frequency of physical activity

People with stroke carried out 5308 (95% CI 3171 to 7445) fewer activity counts than healthy controls. They carried out significantly fewer steps, transitions, and stair ascents and descents than healthy controls. After adjusting the observation period to 12 hr, they still carried out 4062 (95% CI 1787 to 6337) fewer activity counts than healthy controls (Table 3).

## Discussion

This study found that ambulatory stroke survivors carry out less free-living physical activity both in terms of duration (time spent on feet) and frequency (activity counts) than age-matched healthy controls. No difference was found in terms of the time spent not on feet (sitting, reclining, or lying). However, the period of time that stroke survivors were observed was shorter than for healthy controls. When data were adjusted to a standard observation period, the stroke survivors still carried out fewer activity counts but were on their feet for a similar amount of time, ie, although stroke survivors spent less absolute time on their feet than healthy controls, in relative terms it was much the same. The difference in the duration of the observation period between the stroke survivors and healthy controls therefore explains the difference in duration but not frequency of free-living physical activity.

In terms of duration, the stroke survivors spent 10.8 hr (SD 3.6) being observed versus the healthy elderly who spent 12.7 hr (SD 3.3), a difference of 1.9 hr (95% CI 0 to 3.8). While this difference in observation period between the stroke survivors and healthy controls may be partially explained by a general slowness of movement which would result in a longer time to get dressed and undressed, it is probably mainly the result of spending a longer time in bed. When the data were adjusted, our finding that ambulatory stroke survivors spend the same relative amount of time physically active as age-matched healthy controls also concurs with the only previous study to measure duration of physical activity (Sakamoto et al 2008). Interestingly, in both studies there was little difference between groups in the relative amount of time spent walking – the main difference was the shorter time spent standing by people with stroke.

In terms of frequency, our finding that ambulatory stroke survivors carry out fewer activity counts than age-matched healthy controls concurs with previous studies (Manns et al 2009, Hale et al 2008, Sakamoto et al 2008). It is difficult to compare the activity counts from different studies directly because different activity monitors are used and the definition of an activity count differs between studies. However, we can examine the frequency carried out by the stroke survivors as a proportion of that carried out by healthy controls across studies to get an overall estimate of the deficit in physical activity in ambulatory stroke survivors. Our stroke survivors carried out 52% of the activity counts of our age-matched controls. This is similar to Sakamoto et al (2008, 56%), Manns et al (2009, 50%) and Hale et al (2008, 51%). Importantly, the ambulatory ability of stroke survivors across studies was similar, with average walking speed ranging 0.72–0.80 m/s. Therefore, the stroke survivors walked at about 60–67% of healthy elderly walking speed (1.2 m/s, Bohannon 1997), and were physically active at 50–56% of the frequency of age-matched controls. That is, the deficit in the frequency of physical activity can be largely explained by the slowness of movement by the stroke survivors. This is not surprising since speed is a function of frequency and duration.

Comparing the raw and adjusted data provides some interesting insights into the nature of the differences in physical activity between people after stroke and healthy controls. The raw data indicate that people after stroke spend less time on their feet and have fewer activity counts. However, when adjusted to a fixed observation period, the

differences in time on feet disappear but the differences in activity counts remain. This suggests that the reduction in physical activity observed after stroke is because of slowness of movement (ie, fewer counts in an equivalent time period) rather than a diminished amount of time spent being active. This slowness of movement is the result of the severity of the motor impairments, which in turn produce limitations in activity, particularly in walking. The question that arises is whether the observation that ambulatory stroke survivors take about 6000 steps/day (Manns et al 2009, Sakamoto et al 2008), which is well below the recommended level of 10 000 steps/day (Lindberg et al 2000), is putting them at risk of recurrent stroke and cardiovascular events (Gordon et al 2004, Stroud et al 2009). It is interesting to note that the energy expenditure required by stroke survivors to perform routine walking is 1.5 to 2.0-fold that of healthy controls (Gerson and Orr 1971). This suggests that if stroke survivors spend much the same amount of time physically active as age-matched healthy controls, the increase in energy expenditure required to carry out even the reduced activity counts may be much the same as normal. This would mean that they were no more at risk of recurrent stroke and cardiovascular events due to low levels of physical activity than their healthy peers. This is supported by the finding that sedentary time accumulated by sitting, reclining, and lying, which has been found to have deleterious effects on health (Hamilton 2008), was no more in the people with stroke than the healthy controls.

These findings have several implications for the clinic. First, measurement of steps may not be the best indicator of physical activity after stroke. Second, in order to set realistic physical activity targets in the community, individual walking speed may need to be taken into account. Third, rehabilitation and community programs that target improvements in movement speed are likely to have the best impact on improving physical activity after stroke.

This study has several limitations. First, even though we included more than twice as many people with stroke as did previous studies, our sample size was still relatively small which may have led to lack of power in some calculations. However, we had enough power to detect a one hour reduction in time spent on feet and a 2500 reduction in activity counts. Second, given that our observation period was two days across two consecutive weeks, we counterbalanced participants across the week. However, some of the day to day variability found may have been due to different participants rather than to different days of the week. Third, given that our procedures resulted in a difference in the observation period between people after stroke and healthy controls, it may have been better to collect data for 24 hours per day, as was done in a recent study using the same device (Sakamoto et al 2008). Last, our findings reflect the physical activity profiles of ambulatory stroke survivors who were mildly to moderately disabled living in the community, and as such, will not be generalisable to a more severe population.

The major finding of our study is that the reduction in physical activity after stroke is primarily not because of less time spent active but rather a decrease in frequency of activity during that time. Future research into physical activity levels after stroke needs to consider energy expenditure because stroke survivors will exhibit a reduced frequency of physical activity due to the nature of their impairments. Ultimately, understanding the energy

requirements of everyday activities after stroke will determine whether stroke survivors are at risk of recurrent cardiovascular events. ■

**Footnote:** <sup>a</sup>MiniSun Company, 935 E. MillCreek Dr., Fresno, California, 93720, USA.

**Ethics approval:** The University of Sydney Human Research Ethics Committee approved this study. All participants gave written informed consent before data collection began.

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**Competing interests:** None declared.

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