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People with Stroke Are Most Sedentary in the Afternoon and Evening

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Sedentary behaviour · Sitting time · Stroke · Movement behaviours · Physical activity

Abstract
Questions: What are the daily temporal patterns of movement behaviours (sedentary time, light-intensity physical activity, and moderate-vigorous physical activity) in people with stroke? Do daily temporal patterns of sedentary time differ (a) between subgroups of people with different movement behaviour classifications and (b) over time during the first year after stroke? ***Design:*** This study represents secondary exploratory analyses from an observational, longitudinal cohort study (n = 197). ***Participants:*** This study included people with first-ever stroke recruited from 4 hospitals in the Netherlands. ***Outcome Measures:*** Movement behaviour was objectively measured using the Activ8 activity monitor within 3 weeks after hospital discharge and again at 6 and 12 months later. ***Results:*** Participants spent the least time sedentary in the morning with proportionally more sedentary time as the day progressed with maximal sedentary time seen in the evening hours. This pattern did not substantially change over time. *Sedentary prolongers* spent significantly more absolute time sedentary for each hour of the day, but the daily temporal pattern of sedentary time did not differ between this group and either "*sedentary movers*" or "*sedentary exercisers*." ***Conclusion:*** People living at home after stroke are highly sedentary, particularly in the afternoons and evenings, and this pattern does not change during the first year after stroke. Clinicians should encourage people with stroke to find meaningful tasks to do during the day to reduce their sitting time. Researchers developing interventions to encourage people to sit less should include particular focus on the afternoon and evening time periods.

Introduction

People with stroke spend most of their waking hours sedentary (sitting or lying down) and rarely engage in physical activity of at least moderate intensity [1–3]. A harmonized meta-analysis of objective activity monitor data from 36,383 adults found sedentary time >9.5 h a day was associated with 2.5 times greater risk of death [4]. The negative effects of sitting time can be offset by moderate or vigorous intensity exercise [4]. People with stroke are

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at particular risk, with both high sitting time (weighted mean average sitting time from 6 studies 9.5 h/day [3]) and low physical activity [2, 3]. Prolonged bouts of uninterrupted sitting is associated with higher blood pressure [5, 6] and larger swings in postprandial glucose levels [6], both of which are stroke risk factors. Developing interventions to reduce or break up daily sedentary behaviour in people with stroke is a promising new avenue for reducing secondary stroke risk.

Effective interventions require careful development, including consideration of *who* the target population is and *when* we should intervene [7]. Our recent "RISE-cohort" study identified *who* we should target for sedentary behaviour interventions [8]. The RISE study identified 3 distinct movement behaviour classifications early after stroke: *sedentary exercisers*, *sedentary movers*, and *sedentary prolongers* [8]. The *sedentary prolongers* group accumulated sitting time in long, uninterrupted bouts, and spent little time in physical activity of at least moderate intensity [8], and is therefore the target group for sedentary behaviour interventions. In order to further understand *when* and *how* to intervene to reduce sedentary behaviour after stroke, we need to understand daily temporal movement patterns in people after stroke (the time of day when most and least sedentary behaviour occurs) and whether these change over time.

Therefore, our research questions were the following:

1. What are the daily temporal patterns of movement behaviours (sedentary time, light-intensity physical activity, and moderate-vigorous physical activity) in people with stroke?
2. Do daily temporal patterns of sedentary time differ between subgroups of people with different movement behaviour classifications?
3. Do daily temporal patterns of sedentary time change during the first year after stroke?

Method

Design

These are secondary exploratory analyses from an observational, longitudinal cohort study (RISE-cohort) [8]. Full details of the methods for the RISE study are reported elsewhere [8]. In brief, people with first-ever stroke were recruited from 4 hospitals in the Netherlands between February 2015 and April 2017. Movement behaviour was measured at 3 weeks after hospital discharge and again at 6 and 12 months after discharge. In compliance with the Declaration of Helsinki, ethical approval was obtained from the Medical Ethics Research Committee of the University Medical Centre, Utrecht (approval: WG/om/14/010287). All participants provided written informed consent before data collection commenced. Eligible participants were people with first-ever stroke, aged over 18 years, independent in activities of daily living before stroke (Barthel Index score >18), and able to walk with supervision or independently at the time of discharge home (Functional Ambulation Classification score ≥3).

Outcome Measures

A number of demographic and stroke-related variables as well as measures of physical and psychological variables were collected at the first assessment time point in order to describe the sample. Collected variables related to movement behaviour classifications included education level (Dutch classification system), smoking history (pack-years), alcohol intake (drinks/day), stroke severity (National Institutes of Stroke Scale), activity limitations (Late-Life Function and Disability Index [9]), and self-efficacy (Self-efficacy for Symptom Management scale [10]).

Movement behaviour was objectively measured using the Activ8 activity monitor (Remedy Distribution Ltd., Valkenswaard, The Netherlands). This small device (30 mm × 32 mm × 10 mm by 20 g) was worn in the participants' front trouser pocket during waking hours and recorded activity over 2 consecutive weeks. The Activ8 has been shown to record accurate and valid movement data for different postures (sitting/lying [sedentary], standing, walking, and cycling) in people with stroke [11]. The monitor also calculates metabolic equivalent (MET) values for energy expenditure. Participants were asked to keep a daily diary of monitor wear time. At the end of 2 weeks, participants mailed the monitors back to the researchers, data were downloaded into the propriety software, non-wear periods were removed (see below), and summary data were exported to SPSS version 25.0. We identified non-wear time by cross-checking the diary-recorded wear time each day with the raw data. A valid wear day was defined as including at least 10 h of wear time, and only data from participants with at least 7 days of valid wear time were included at each time point.

Exported summary data included minutes spent in different movement behaviours (sedentary, light physical activity [LPA], and moderate-to-vigorous physical activity [MVPA]) per hour between 9:00 a.m. and 11:00 p.m. Data were averaged for each person across all valid wear days and therefore represent habitual activity [12]. Per hour percentages were calculated for sedentary behaviour, LPA, and MVPA.

Data Analysis

Ignoring missing data, by restricting the analyses to subjects with complete data, can lead to biased results if missing values are not *missing completely at random*. We performed a missing value analysis which showed our data were *missing at random*, i.e., missing data depended on other observed data [13]. Participants with incomplete data were more often female. Therefore, multiple imputation was performed using Multivariate Imputation by Chained Equation by the missing at random method [14]. The percentage per hour spent sedentary, in LPA, and in MVPA is reported using descriptive statistics. We used generalized estimating equations (GEEs) with an exchangeable correlation structure to explore the change in percentages in sedentary activities, LPA, and MVPA across the day. We also used GEE to explore differences in the temporal patterns of sedentary time (a) between subgroups of participants with different movement behaviour classifications and (b) between data collected at 3 weeks, 6 months, and 12 months after discharge. We set significance at $p < 0.05$ and planned to adjust for multiple comparisons in the case of statistically significant results.

Table 1. Characteristics of participants

Characteristic	Total group (*n* = 197)
Age, mean (SD), years	68 (11)
Gender, male, *n* (%)	128 (65)
Completed at least *x* years at school, *n* (%)	61 (31)
Smoking, mean (SD), pack-years	8 (13)
Light drinkers, *n* (%)	114 (58)
Stroke characteristics	
Side of hemiplegia, left side, *n* (%)	104 (53)
Stroke severity (NIHSS), *n* (%)	
No symptoms (score 0)	26 (13)
Minor symptoms (score 1–4)	108 (55)
Moderate-severe symptoms (score ≥5)	63 (32)
Physical function and self-efficacy	
Activity limitations LLFDI (score 0–100), mean (SD)	56 (11)
High self-efficacy SESx score ≥115, *n* (%)	30 (15)

NIHSS, National Institutes of Health Stroke Scale; LLFDI, Late-Life Function and Disability Index; SESx, Self-efficacy for Symptom Management scale.

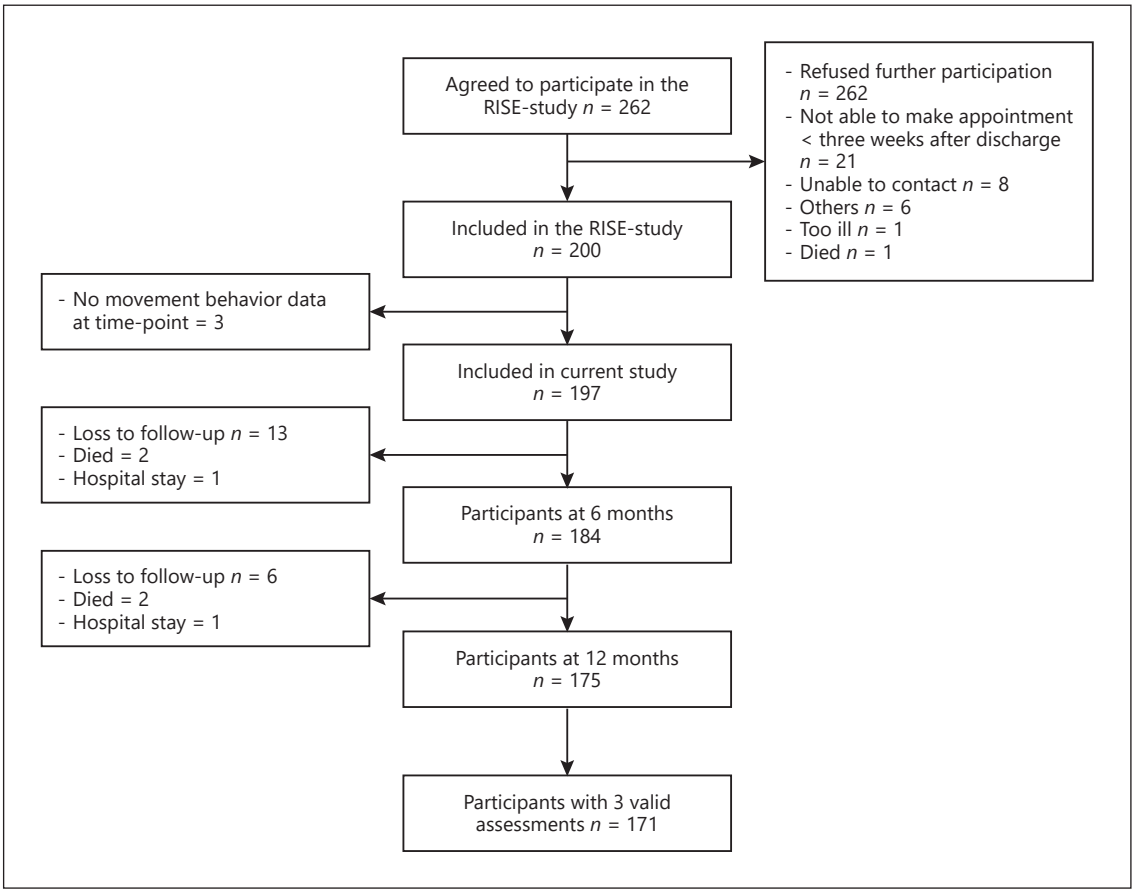

Fig. 1. Flow of participants through the study.

Table 2. Percentage of each hour spent in movement behaviours at 3 weeks, 6 months, and 12 months after stroke

	9:00 a.m.	10:00 a.m.	11:00 a.m.	12:00 p.m.	1:00 p.m.	2:00 p.m.	3:00 p.m.	4:00 p.m.	5:00 p.m.	6:00 p.m.	7:00 p.m.	8:00 p.m.	9:00 p.m.	10:00 p.m.
3 weeks														
Sedentary	60 [58–62]	60 [58–62]	61 [59–63]	63 [61–65]	66 [64–68]	66 [64–68]	66 [65–68]	65 [63–67]	67 [65–68]	71 [70–73]	73 [71–75]	76 [74–78]	77 [75–79]	76 [74–78]
LPA	34 [32–6]	33 [31–35]	33 [31–35]	32 [30–34]	29 [27–31]	28 [26–30]	28 [26–29]	30 [28–32]	30 [28–31]	25 [24–27]	24 [22–25]	22 [20–23]	21 [19–22]	22 [20–23]
MVPA	6 [5–6]	7 [6–8]	6 [6–7]	5 [5–6]	6 [5–7]	6 [5–7]	6 [5–7]	5 [4–6]	4 [3–4]	3 [3–4]	3 [2–3]	2 [2–3]	2 [2–3]	2 [2–3]
6 months														
Sedentary	58 [56–61]	59 [57–61]	59 [57–61]	62 [61–64]	61 [59–63]	62 [60–63]	63 [61–65]	64 [62–66]	65 [63–67]	69 [67–71]	72 [70–74]	76 [74–78]	78 [77–80]	79 [77–80]
LPA	34 [32–6]	33 [31–34]	33 [31–35]	31 [29–32]	31 [29–33]	30 [28–32]	29 [28–31]	29 [28–31]	30 [29–32]	27 [5–29]	24 [23–26]	21 [19–23]	19 [18–21]	19 [18–21]
MVPA	8 [7–9]	8 [7–9]	8 [7–9]	7 [6–8]	8 [7–9]	8 [7–9]	8 [7–9]	6 [6–7]	5 [4–5]	4 [3–5]	4 [3–5]	3 [2–3]	2 [2–3]	2 [2–2]
12 months														
Sedentary	58 [56–61]	59 [7–61]	60 [58–62]	63 [62–65]	64 [62–65]	63 [62–65]	65 [63–67]	65 [63–66]	66 [64–68]	70 [68–72]	73 [71–75]	76 [74–77]	77 [76–79]	76 [74–78]
LPA	35 [33–37]	33 [31–35]	33 [31–35]	31 [29–32]	30 [28–32]	29 [27–31]	28 [26–30]	29 [27–31]	29 [28–31]	26 [24–28]	23 [22–25]	21 [20–23]	20 [19–20]	22 [20–23]
MVPA	7 [6–8]	8 [7–9]	7 [6–8]	6 [5–7]	7 [6–7]	8 [7–9]	7 [6–8]	6 [5–7]	5 [4–5]	4 [3–4]	4 [3–4]	3 [3–4]	3 [2–3]	2 [2–3]

Values are mean [95% confidence interval]. Total percentages per hour may not be exactly 100% due to rounding.

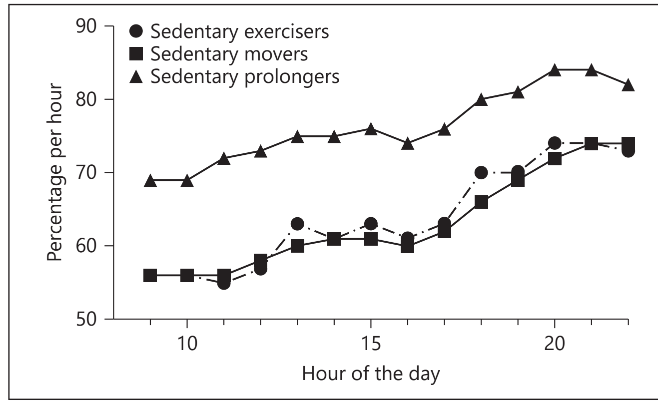

Fig. 2. Temporal patterns in sedentary time. Each line represents a different movement behaviour classification (*"sedentary exerciser," "sedentary mover," and "sedentary prolonger"*).

Results

A total of n = 197 participants had valid movement behaviour data at least one time point (demographics shown in Table 1). This number reduced to n = 184 at 6 months and n = 174 at 12 months (see Fig. 1 for participant flow through the study). Table 2 and online supplement 1 (for all online suppl. material, see www.karger.com/doi/10.1159/000521209) present data for the time spent in movement behaviours between 9:00 a.m. and 11:00 p.m. each day.

At 3 weeks after discharge, participants spent the least time sedentary between 9:00 a.m. and 11:00 a.m. (60% of each hour) with proportionally more sedentary time per hour as the day progressed (maximum 76–77% of each hour between 8:00 p.m. and 11:00 p.m.). Daily temporal patterns of LPA were essentially the reverse of sedentary time. Participants spent more time in MVPA during the morning hours (6–7% of each hour between 9:00 a.m. and 12:00 p.m.) compared with evening hours (2% of each hour between 8:00 p.m. and 10:00 p.m.).

All participants spent significantly less time sedentary in the morning (B 61, 95% CI: 59–63, $p < 0.001$) compared to the afternoon (dif B, five, 95% CI: 4–6) and evening (dif B 14, 95% CI: 12–15), and this temporal pattern did not differ between *sedentary exercisers, sedentary movers*, or *sedentary prolongers*. *Sedentary prolongers* spent significantly more absolute time sedentary for each hour of the day (see online supplements 2, 3; Fig. 2). The GEE analysis found a significant difference in the daily temporal pattern of sedentary time at 6 (B −1% [95% CI −2 to 0], $p < 0.01$) and 12 (B −1 min [95% CI −1 to 0], $p < 0.01$) months, but the magnitude of these differences was negligible (see online supplement 4).

Discussion

This study reports secondary, exploratory analyses from a cohort of people discharged to the home setting within 3 weeks of stroke in the Netherlands. We found that people with stroke were highly sedentary across the whole day, with the proportion of each hour spent sedentary increasing across the day. The sharpest increase in sedentary time occurred from late afternoon onward. The time spent in LPA essentially mirrored that of sedentary time. Only a very small proportion of each hour was spent in MVPA. Not surprisingly, the absolute values of sedentary time per hour were higher in the *sedentary prolongers* group compared with both the *sedentary movers* and *sedentary exercisers* groups. However, the daily temporal pattern of sedentary time did not differ between the different movement behaviour patterns or over time during the first year after stroke.

The primary aim of the RISE-cohort study was to identify groups of people with different movement behaviour classifications. Three distinct movement behaviour patterns were identified, but sedentary time was high in all people within the cohort, regardless of movement classification [8]. The magnitude of daily sitting time in our cohort (>8.5 h per day, >63% of waking hours) approached the threshold of sedentary time associated with an exponential increase in risk of all-cause mortality [15] and cardiovascular disease [4]. Therefore, the development of interventions to support "moving more and sitting less" is warranted for all people with stroke.

Only one previous study has reported daily temporal patterns of sedentary behaviour in people with stroke [16]. Similar to our study results, they found a pattern of increasing sedentary time across the day that was consistent across the first year after stroke. Tieges et al. [16] did not remove sleep or non-wear time from their activity data, meaning that estimates of sedentary time may not have been accurate, particularly during morning and evening hours where sedentary time may be conflated with sleep time. Our results also mirror that of older adults without chronic illness who also tend to spend more time sedentary in the afternoon and evening [17].

We now have many studies that show that people with stroke are highly sedentary [3], and this current analysis provides information about *when* during the day people are most sedentary. In order for clinicians and researchers to develop effective interventions, we also need to understand *why* people choose to be sedentary. Qualitative work has found that people with stroke have limited awareness of the health risks of sedentary behaviour and therefore do not make conscious choices to move based on perceived health benefits [18]. Older adults report that regular daily routines (e.g., meal preparation) and doing household chores as key reasons to get up and move around [19]. By contrast, people with stroke rarely engage in household chores [2], with caregivers often taking over these roles [18]. People who are socially isolated also spend more time sedentary compared with those who are less isolated [19]. Supporting people with stroke to participate in everyday chores and encouraging social activities in the community may be 2 ways of reducing sedentary behaviour in this population.

Strengths and Limitations

Only people who could walk at least short distances with supervision (FAC ≥3) with minimal communication difficulties were included in our study. However, the relatively large cohort size (n = 197) means we can be confident that our data are representative of this subgroup of people with stroke. Movement behaviours were objectively measured using the Active8 monitor. This monitor has been shown to be highly accurate in correctly identifying postures (e.g., sitting vs. standing) and movements (e.g., walking and cycling) in people with stroke [11] and people in the hospital [20]. Energy expenditure estimates from the Active8 have also been found to be accurate in healthy people compared to indirect calorimetry [21]. The Activ8 is worn in the thigh pocket of trousers. Female participants may have chosen to wear skirts or trousers without pockets on some days. Thigh straps were made available to mitigate this risk. This is a limitation of the Activ8 monitor and may be a reason for more missing data from female participants. We did not collect data on ethnicity or whether participants had family or carer support at home, so we were not able to explore the influence of these factors on movement behaviour.

Conclusion

People living at home after stroke are highly sedentary, particularly in the afternoons and evenings, and this pattern does not change during the first year after stroke. Clinicians should encourage people with stroke to find meaningful tasks to do during the day to reduce their sitting time. Researchers developing interventions to encourage people to sit less should include particular focus on the afternoon and evening time periods.

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Statement of Ethics

In compliance with the Declaration of Helsinki, the Medical Ethics Research Committee of the University Medical Centre, Utrecht Ethics Committee(s), approved this study (approval: WG/om/14/010287). All participants gave written informed consent before data collection commenced.

Conflict of Interest Statement

The authors have no conflicts of interest to declare. C. English is an Associate Editor of *Cerebrovascular Diseases*.

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Author Contributions

C. English contributed to conceptualization, methodology, writing – original draft preparation, editing and submission, and supervision. R. Wondergem contributed to conceptualization, methodology, formal analyses, visualization, and writing – review and editing. W. Hendrickx contributed to conceptualization and writing – review and editing. M. Pisters contributed to conceptualization, methodology, writing – review and editing, funding acquisition, and supervision.

Data Availability Statement

Consent from participants was not obtained for data sharing.

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