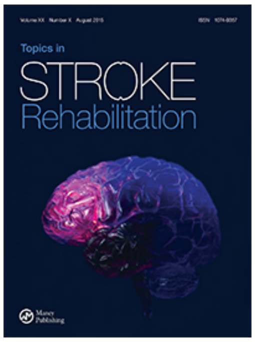

Topics in Stroke Rehabilitation

ISSN: 1074-9357 (Print) 1945-5119 (Online) Journal homepage: http://www.tandfonline.com/loi/ytsr20

Excessive sedentary time during in-patient stroke rehabilitation

Matthew Barrett, John Charles Snow, Megan C. Kirkland, Liam P. Kelly, Maria Gehue, Matthew B. Downer, Jason McCarthy & Michelle Ploughman

TOPICS IN STROKE REHABILITATION, 2018
https://doi.org/10.1080/10749357.2018.1458461

ORIGINAL ARTICLE

Excessive sedentary time during in-patient stroke rehabilitation

Matthew Barrett[a], John Charles Snow[a], Megan C. Kirkland[a], Liam P. Kelly[a], Maria Gehue[a], Matthew B. Downer[a], Jason McCarthy[a,b] and Michelle Ploughman[a]

[a]Recovery & Performance Laboratory, Faculty of Medicine, Memorial University of Newfoundland, St. John's, Canada; [b]Rehabilitation and Continuing Care Program, Eastern Health Authority, St. John's, Canada

ABSTRACT

Background and Purpose: Previous research suggests that patients receiving inpatient stroke rehabilitation are sedentary although there is little data to confirm this supposition within the Canadian healthcare system. The purpose of this cross-sectional study was to observe two weeks of inpatient rehabilitation in a tertiary stroke center to determine patients' activity levels and sedentary time.
Methods: Heart rate (HR) and accelerometer data were measured using an Actiheart monitor for seven consecutive days, 24 h/day, on the second week and the last week of admission. Participants or their proxies completed a daily logbook. Metabolic equivalent (MET) values were calculated and time with MET < 1.5 was considered sedentary. The relationship between patient factors (disability, mood, and social support) and activity levels and sedentary time were analyzed.
Results: Participants (*n* = 19; 12 males) spent 10 h sleeping and 4 h resting each day, with 86.9% of their waking hours sedentary. They received on average 8.5 task-specific therapy sessions; substantially lower than the 15 h/week recommended in best practice guidelines. During therapy, 61.6% of physical therapy and 76.8% of occupational therapy was spent sedentary. Participants increased their HR about 15 beats from baseline during physical therapy and 8 beats during occupational therapy. There was no relationship between sedentary time or activity levels and patient factors.
Discussion: Despite calls for highly intensive stroke rehabilitation, there was excessive sedentary time and therapy sessions were less frequent and of lower intensity than recommended levels.
Conclusions: In this sample of people attending inpatient stroke rehabilitation, institutional structure of rehabilitation rather than patient-related factors contributed to sedentary time.

ARTICLE HISTORY
Received 8 November 2017
Accepted 25 March 2018

KEYWORDS
Activity; stroke; monitoring; exertion; participation; inpatient; rehabilitation

Introduction

Due to an aging population, decreased stroke mortality, and increasing prevalence of cardiovascular risk factors, it is estimated that by 2030 there will be nearly 70 million stroke survivors worldwide.[1] Robust preventative measures are clearly needed, however, days after the stroke has occurred, rehabilitation remains the only treatment available. Intensive rehabilitative interventions such as constraint-induced movement therapy,[2,3] virtual reality[4], and task-specific training[5–7] target neuroplasticity to improve functional outcomes, however experts agree that interventions provided within the "critical period" of recovery, when the brain is most amenable to change, provide optimal results.[8] Despite these assertions, therapy that is provided on acute stroke and rehabilitation units is reported to be of low intensity[9–11] and stroke patients have been described as "inactive and alone".[12] Using accelerometry, Mattlage et al. showed that while on an acute stroke unit, patients spent about 94% of their time sedentary.[13] Sjoholm and group observed 104 patients in rehabilitation hospitals in Sweden and reported that 74% of time was spent sedentary.[14] This excessive sedentary time is cause for concern since long durations of sedentary time increase cardiovascular risk[15] and result in deconditioning. For instance, in the Dallas Bedrest Study, young men who received 3 weeks of bed rest experienced greater losses in cardiorespiratory fitness than that experienced after 30 years of aging.[15] Researchers have made attempts to increase intensity of stroke rehabilitation by adding Saturday treatments[16,17] and by mobilizing patients much earlier[18] with varying results.

Inpatient stroke rehabilitation is provided by an interdisciplinary team of health providers including nurses, physicians and therapists, among others; yet assessments of activity within stroke units has focused on physical therapy (PT) and occupational therapy (OT) sessions during the work day (i.e. 9:00 am–5:00 pm).[9,12,19] Aside from structured rehabilitation sessions provided within PT and OT sessions, little is known about how active or how sedentary patients are throughout the day or on weekends. There could be opportunities for nurses, families, and volunteers to provide enrichment to break up sedentary time and/or increase activity to prevent deconditioning and optimize the rehabilitation effort.

CONTACT Michelle Ploughman michelle.ploughman@med.mun.ca

In addition to the structure of the rehabilitation program, there could also be patient-related factors that affect sedentary time such as severity of stroke, pre-existing health conditions, depression, and degree of social support.[20–22] Sedentary time, therefore, could be due to both institutional (structures, processes, environment, and staffing) and patient factors. However, previous work has assessed sedentary time post-discharge, focusing on the influence of patient factors.[20,21,23]

The goal of this study was to map sedentary time, using activity counts, heart rate (HR), and detailed log of activities, 24 h per day, seven days a week among patients in a typical Canadian publically funded inpatient stroke rehabilitation unit. We also wished to test the usability of Actigraph and its associated software (CamNtech Ltd and CamNtech Inc, England, UK). In order to accurately represent sedentary time, we aimed to collect data during the second week of admission (admission week) and during the last week of admission (discharge week) for consecutive patients admitted to the unit during one quarter of a year (3 months). Based on previous research in activity levels,[13,14] we hypothesized that there would be long durations of sedentary time, with greater sedentary time on the weekends than on the weekdays. We also hypothesized that lower levels of social support, higher levels of disability, and more depressive symptoms would be related to greater percentages of waking hours spent sedentary. The overarching aim was to identify opportunities to enrich the rehabilitation experience to promote recovery.

Methods

Data collection site

Following approval by the local research ethics board, data was collected from consecutive patients (after providing consent) admitted to a tertiary 22-bed stroke rehabilitation unit serving a population of about 500,000. Patients arrived at the rehabilitation unit from acute care services in rural and urban hospitals (median) 8 days post-stroke. Criteria for admission included the ability to fully participate in therapies for at least 3 h, five days per week, with a high likelihood of returning home with or without supports. Individual PT and OT sessions were provided five days per week. In addition, eligible patients were encouraged to attend organized leisure activities and one or two supplementary arm rehabilitation group sessions per week.[24] The rehabilitation unit contributes performance data to the National Rehabilitation Reporting System (Canadian Institute for Health Information), which reports that, on average, patients are admitted to rehabilitation units in Canada with an average total function score (Functional Independence Measure out of 126) of 75 and discharge score of 95.[25]

Participants

Participants were new patients admitted with their first disabling stroke who were older than 18 years of age and they or their family member was able to provide informed consent. Participants were excluded if the admission was expected to be less than 3 weeks or if they had another neurological disorder in addition to stroke, such as Parkinson's disease. Demographic information and characteristics of the stroke (age, height, weight, co-morbid conditions, date of onset, date of admission, stroke location, and medications) were extracted from health records.

Outcome measurements

Measurement took place continuously for two episodes; 7 days beginning one week following admission (Admission week) and another 7 days beginning one week before discharge (Discharge week).

Activity log

The Log was a seven page booklet (one page for each day) with time divided into 30 min blocks. Previous studies have shown that such logs are a feasible method for determining sedentary time/physical activity and for quantifying energy expenditure in hospitalized stroke patients.[26] Participants and their caregivers were instructed how to record activities and were visited twice per day by a research assistant to help complete the Log and compare recorded activities with the participant's daily rehabilitation schedule. Activities recorded in the Log were grouped into eight domains: rest, activities of daily living (ADL), leisure, PT, OT, other therapies (psychology and speech language pathology), sleep, and miscellaneous. Leisure consisted of activities that participants chose to do in their spare time, for example, watching television, reading books, or spending time with family. Miscellaneous activity included activities that did not fit into the other categories such as falling out of bed.

Activity and sedentary time

HR and activity counts, in time-stamped 15 s epochs, were measured using the Actiheart monitor (CamNtech Ltd and CamNtech Inc, England, UK) which was positioned over the heart using two ECG electrodes (3M Red DotAg/AgCl). The skin area was cleaned, shaved, and abraded for optimal electrode contact. Accurate placement of the device was ensured by using the signal test option from the Actiheart software, which measures *r*-wave amplitude of the heart along with the level of noise affecting the signal. The participant's device was checked twice a day to ensure proper contact. Data from the Actiheart was uploaded into the software package where HR and activity counts were used to calculate metabolic equivalents (METs). We also recorded methodological issues with the Actiheart such as skin preparation, electrode attachment, cleaning, and data extraction.

Stroke severity and disability

Severity of the stroke was scored using the National Institute of Health Stroke Scale (NIHSS).[27] The scale ranges from 0 to 15 with higher values indicating greater severity. It is highly valid and reliable when comparing to an individual's medical records with an interrater reliability reported at 0.82, sensitivity 0.72, and specificity 0.89.[27] Level of disability was measured using the Barthel Index, a validated measure in stroke that includes 10 tasks (feeding, toileting, mobility, etc.)[28,29] with scores range from 0 to 100 with higher values representing higher level of independence.

Social support

Social support was measured using the Personal Resource Questionnaire version 2000 (PRQ-2000); a reliable and valid resource for measuring social support in various populations.[30]

Internal consistency of the tool ranges from 0.87 to 0.93 and it shows divergent validity when compared to the Center for Epidemiological Studies Depression.[30] Scores ranged from 15 to 105, with higher scores representing greater social support.

Mood

Mood was evaluated using the Hospital Anxiety and Depression Scale (HADS)[31] which has been validated in stroke patients.[32] The scale can be split to differentiate depression (HADS-D) and anxiety (HADS-A) symptoms. Internal consistency in 101 stroke patients was reportedly high (0.89 for HADS-A and 0.83 for HADS-D) and with a total cut-off score of ≥7, sensitivity was 0.70, and specificity was 0.71.[30] This scale is represented with values from 0 to 21. Values between 0 and 7 are deemed normal mood responses, 8–10 borderline abnormal, and 11–21 as abnormal.

Data analysis

Total and average activity counts, total time and average HR were determined for each activity category separated by weekday or weekend. In order to measure exertion (increase in HR from rest) during scheduled therapies, resting HR was determined by calculating the average HR during the "Rest" category over the seven days for each participant. Time spent at MET < 1.5 was considered to be sedentary.[33] Number and lengths of blocks of sedentary time were calculated where a "block" was considered to be ≥60 min and a break in a block was considered as a five-minute average of MET ≥ 1.5.

Pearson correlation analysis was used to examine the relationships between stroke severity, disability, mood, or social support and total activity counts and sedentary time. Additionally, changes from admission to discharge week and differences in sedentary time between weekday and weekend were determined using paired sample t-tests. Data was analyzed using IBM SPSS Statistic Software v22 with a significance set at $p < 0.05$. The STROBE statement was used to guide the reporting of study findings.[34]

Results

Participant demographics

Twenty-eight newly admitted stroke patients were approached to participate and 19 participants completed seven days of data collection during admission week (Table 1). Data for discharge week was only collected on eight participants. Participants were on average 68 years of age and 39 days post-stroke. According to NIHSS, they had minor to moderate stroke but were moderately disabled (Barthel Index; (Table 1)).

Distribution of activities

Participants spent on average 21% of their day in the category "Rest" both during weekdays (299.67 ± 7.18 min) and weekends (305.79 ± 8.14 min; Figure 1). They spent on average 567.89 ± 2.71 min or 40% of their day asleep during weekdays, and similarly 587.24 ± 6.12 or 41% of Saturday and Sunday sleeping. Participants spent a greater percentage of their time participating in leisure activities during the weekend (385.5 ± 6.60 min; 27%) than during the weekdays (259.11 ± 6.13 min; 18%; $t = 5.08$, $p < 0.01$). Therapies were only offered on weekdays. Participants spent on average 48.00 ± 0.76 min or 3% of the day in PT, 39.79 ± 0.74 min or 3% of the day in OT, and 18 ± 0.94 min or 1% of their day in other therapies (Figure 1).

Table 1. Participant characteristics.

Characteristics	Mean ± SD (range)
Gender	7 females; 12 males
Age	68.2 ± 9.8 (48–88)
Type of stroke	2 hemorrhagic; 16 ischemic
Side of brain	11 left; 6 right; 2 bilateral
Days since stroke[a]	38.8 ± 33.4 (16–150)
Stroke Severity (NIHSS)	4.7 ± 3.3 (1–14)
Degree of disability (Barthel Index)	55 ± 26.4 (0–100)
Depression (HADS-D)	5.1 ± 3.8 (0–21)
Anxiety (HADS-A)	6.0 ± 3.5 (1–14)
Social Support (PRQ-2000)	90.9 ± 10.5 (63–102)

[a]Days since stroke calculated as the time from stroke to participants' first day of data collection; SD: standard deviation; NIHSS: National Institute of Health Stroke Scale; HADS: Hospital Anxiety and Depression Scale (D: Depression, A: Anxiety); PRQ-2000: Personal Resource Questionnaire.

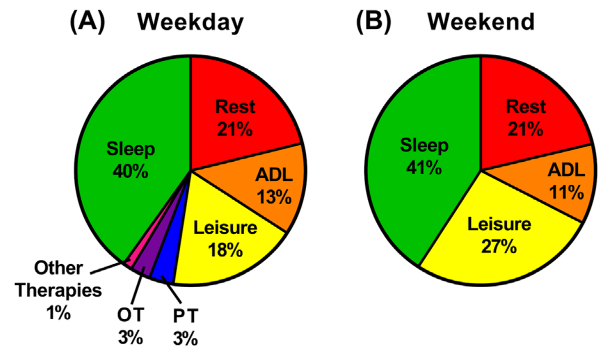

Figure 1. Average percentage time spent in activity categories on weekday and weekend.
Notes: Distribution of time spent in various activities during an average (A) weekend and (B) weekday; ADL: Activities of daily living; PT: physical therapy; OT: occupational therapy.

Sedentary time

On weekdays, participants spent on average 12.75 h/day (85.56 ± 18.21%) of their waking hours sedentary, which significantly increased to 13.5 h/day (89.84 ± 14.62%) on the weekend ($t = -3.67$, $p < 0.01$; Table 2). When considering the long blocks of time in which participants were sedentary, we found that during a weekday, participants had an average of 2.23 ± 1.13 blocks per day, these blocks were on average, 318.84 ± 219.89 min (5.31 h) long. On the weekend, there was no change in the number of sedentary blocks (2.37 ± 1.43; $t = -0.45$, $p = 0.66$), but the average length of these sedentary blocks significantly increased to 408.98 ± 296.59 min (6.82 h) ($t = -2.86$, $p = 0.01$; Table 2). The time of day in which sedentary blocks typically occurred was between 11:00 and 13:00 (lunchtime) and 15:00 onward (evening; Figure 2). Similar patterns occurred during discharge week, as participants spent 88.32 ± 10.10% of weekdays and 92.14 ± 9.08% of weekends sedentary. For the participants with available data during discharge week, there was no difference in sedentary time ($t = -0.49$, $p = 0.64$; $t = -0.53$, $p = 0.61$), number of sedentary

Table 2. Sedentary time.

	Admission week						Discharge week					
	Weekday			Weekend			Weekday			Weekend		
Participant number	% Time seden-tary	Sedentary blocks per day	Length of blocks	% Time sedentary	Sedentary blocks per day	Length of blocks	% Time sedentary	Sedentary blocks per day	Length of blocks	% Time sedentary	Sedentary blocks per day	Length of blocks
1	98.44	1.20	615.43	97.90	1.00	945.00	97.50	2.33	309.29	99.57	3.00	275.00
2	63.78	2.80	119.93	67.74	4.50	92.67	–	–	–	–	–	–
3	93.86	3.00	270.00	94.45	3.00	276.00	–	–	–	–	–	–
4	85.21	3.20	210.25	93.54	4.00	179.75	–	–	–	–	–	–
5	88.90	3.20	209.88	98.99	1.50	596.33	93.56	2.66	267.13	98.78	1.50	557.33
6	88.13	2.40	313.75	93.47	2.00	329.50	92.82	2.60	292.92	92.87	1.50	492.00
7	71.15	2.60	96.85	71.38	4.00	147.75	88.33	3.40	142.56	83.36	4.00	89.25
8	23.47	0.00	0.00	42.96	0.00	0.00	–	–	–	–	–	–
9	97.87	1.80	468.78	98.65	1.50	557.00	–	–	–	–	–	–
10	92.80	3.50	171.71	95.48	4.00	185.50	88.78	3.00	155.78	94.43	2.50	295.20
11	99.37	1.40	639.29	99.84	1.00	795.00	–	–	–	–	–	–
12	88.18	2.40	272.67	95.11	3.00	272.67	–	–	–	–	–	–
13	78.63	4.60	119.70	88.05	2.50	219.20	73.06	3.50	155.14	94.09	4.50	181.89
14	99.71	1.20	711.00	99.52	1.00	885.00	99.29	1.33	646.00	99.99	1.00	870.00
15	96.30	2.60	294.23	98.32	1.50	524.00	–	–	–	–	–	–
16	98.65	1.60	532.13	99.90	1.00	840.00	–	–	–	–	–	–
17	78.36	0.60	141.00	83.16	5.00	110.60	73.22	3.20	115.00	74.00	3.00	102.83
18	83.69	3.00	192.40	90.26	3.00	236.00	–	–	–	–	–	–
19	99.17	1.20	679.00	98.22	1.50	578.67	–	–	–	–	–	–
Average (SD)	85.56[a] (18.21)	2.23 (1.13)	318.84[a] (219.89)	89.84 (18.21)	2.37 (1.43)	408.98 (296.59)	88.32 (10.10)	2.75 (0.70)	260.48 (172.89)	92.14 (9.08)	2.63 (1.25)	357.94 (267.00)

[a]Different from weekend in same week, $p < 0.05$; length of blocks are presented in minutes; empty cells represent missing data; %: percent; SD: standard deviation.

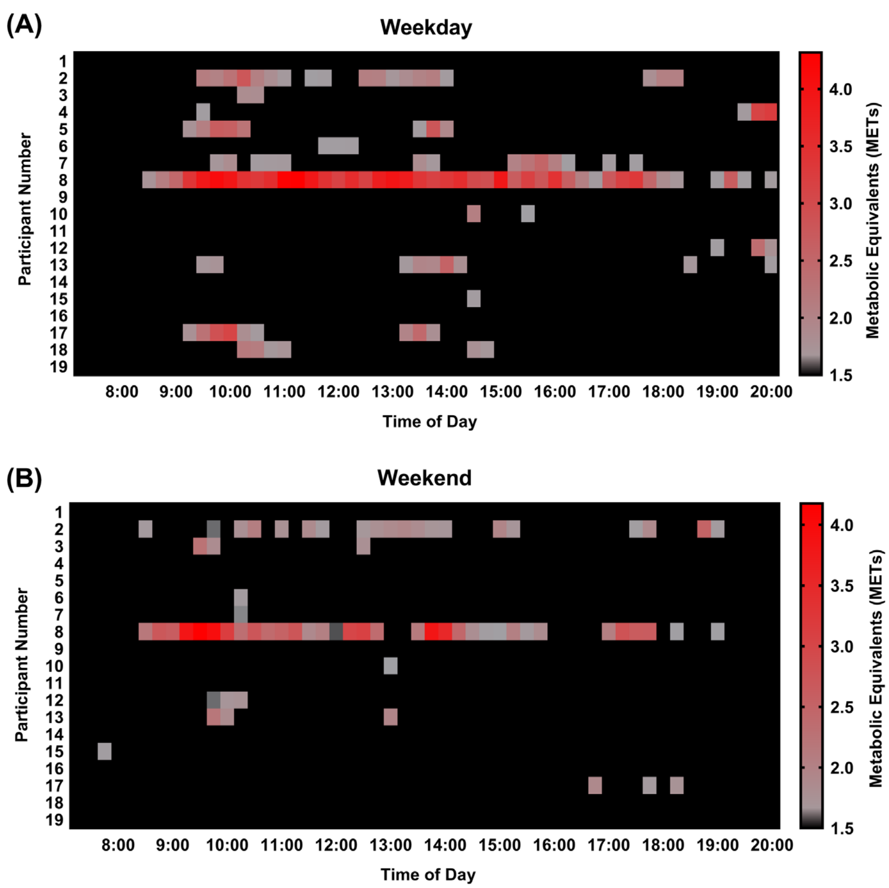

Figure 2. Patterns of sedentary time (≤1.5 METs) during weekday and weekend in 19 participants. Darkest shade (black) indicates MET level ≤1.5 (sedentary). (A) During the weekday, there was some activity between 9 and 11am and between 1 and 3 pm, but otherwise participants were sedentary for long periods of time. Some subjects were nearly always sedentary (#1, 4, 5, 9, 11, 13, 14, 17, 18, 19) and only one participant almost always active (#8). (B) The majority of time was spent sedentary during the weekend.

Table 3. Sedentary and active time during therapy sessions.

	Admission week			Discharge week		
	Therapy per week (hours)	% Sedentary	Average MET	Therapy per week (hours)	% Sedentary	Average MET
PT	3.87 (1.16)	61.57 (36.63)	1.65 (0.73)	3.31 (1.22)	64.07 (28.94)	1.49 (0.43)
OT	3.26 (1.04)	76.83[a] (28.74)	1.38[a] (0.66)	2.62 (1.22)	83.34 (12.49)	1.20 (0.12)
Other Therapy[b]	1.53 (1.47)	79.65 (28.59)	1.37 (0.72)	0.5 (0.87)	95.52 (4.48)	1.09 (0.01)

[a]Significantly different from PT
[b]Other therapy includes psychology and speech language pathology; PT: physiotherapy; OT: occupational therapy; MET: metabolic equivalence values; %: percent. Values are mean (standard deviation).

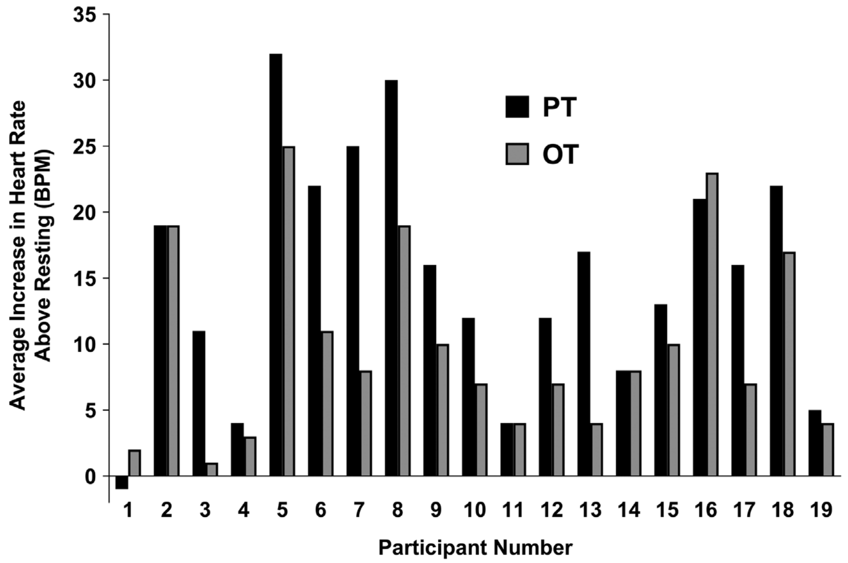

Figure 3. Change in heart rate during therapy.
Notes: Heart rate change is expressed as change in beats per minute above resting heart rate; BPM: beats per minute; PT: physical therapy; OT: occupational therapy.

blocks per day ($t = -0.82$, $p = 0.44$; $t < 0.001$, $p = 1.00$), or average block length ($t = 0.90$, $p = 0.40$; $t = 0.77$, $p = 0.47$) between admission and discharge weeks for weekdays or weekends, respectively.

Therapy sessions

The average number of separate PT sessions attended per week was 4.05 ± 1.19; 3.37 ± 1.2 OT sessions, and 1.50 ± 1.49 other therapy sessions. During PT, participants were sedentary 61.57 ± 35.63% of the time, with an average MET value of 1.65 ± 0.73 (Table 3). OT was significantly more sedentary than PT, as participants spent 76.83 ± 28.74% of sessions sedentary ($t = -2.56$, $p = 0.02$), with an average MET value of 1.38 ± 0.66, significantly lower than PT ($t = 3.75$, $p < 0.01$). Only twelve out of 19 participants attended other therapies, but those who did spent 79.65 ± 28.59% of the sessions sedentary, with an average MET value of 1.37 ± 0.72 (Table 3). There were no differences between admission and discharge weeks for percentage of therapy sedentary (PT: $t = -1.50$, $p = 0.18$; OT: $t = -0.59$, $p = 0.57$) or average MET values (PT: $t = 1.11$, $p = 0.30$; OT: $t = 0.63$, $p = 0.55$; Table 3). In addition to spending a large portion of therapies sedentary, many participants were not active enough to meet requirements for improvement in cardiorespiratory fitness according to their HR values. Average change in HR during PT and OT sessions was calculated using the difference of resting HR and average HR during each therapy (Figure 3). The mean change in HR (beats per minute; BPM) across all participants during PT was 18.16 ± 8.99 BPM, and 9.95 ± 7.24 BPM in OT.

Patient factors were not associated with sedentary time or activity levels

Patient factors such as disability and depressive mood were not associated with the amount of sedentary time or activity counts during inpatient rehabilitation. When entering all 19 participants into the analysis, greater disability (Barthel Index) was associated with a longer sedentary time on weekdays and weekend (Table 4), however, after removing participant #8 (who had no disability (Barthel index = 100) with sedentary time more than 2 SDs below the mean of the remainder of the subjects, the relationship was no longer significant (Table 4). No other variables were associated with sedentary time. Lastly, total activity counts were not associated with stroke severity (NIHSS), time since stroke, social support, anxiety, depression, or disability.

Usability of the Actiheart

Attachment of the electrodes to the chest required extensive shaving of chest hair especially among men. Since data was to be collected for seven continuous days, we pretested methods to secure the Actiheart to the chest such that the wire connecting the leads would not be hooked thereby dislodging the apparatus.

Table 4. Associations between patient factors, sedentary time, and activity counts.

Characteristic	Sedentary time: Weekday	Sedentary time: Weekend	Activity counts
Disability (Barthel index)	**$r = -0.54, p = 0.02$**	**$r = -0.55, p = 0.02$**	$r = 0.37, p = 0.12$
Disability (with outlier removed)	$r = -0.39, p = 0.11$	$r = -0.40, p = 0.10$	$r = 0.02, p = 0.94$
Stroke severity (NIHSS)	$r = 0.17, p = 0.48$	$r = 0.18, p = 0.45$	$r = -0.05, p = 0.85$
Time since stroke	$r = 0.20, p = 0.42$	$r = 0.15, p = 0.55$	$r = -0.23, p = 0.34$
Social support (PRQ-000)	$r = -0.19, p = 0.50$	$r = -0.28, p = 0.28$	$r = 0.19, p = 0.46$
Anxiety symptoms (HADS-A)	$r = 0.44, p = 0.09$	$r = 0.43, p = 0.10$	$r = -0.03, p = 0.23$
Depressive symptoms (HADS-D)	$r = 0.01, p = 0.96$	$r = -0.001, p = 0.99$	$r = -0.36, p = 0.17$

Notes: NIHSS, National Institutes of Health Stroke Scale; PRQ, personal resources questionnaire; HADS, hospital anxiety, and depression scale.
The p values are alongside the r values, $p = 0.02$.

Once the device was charged, and after shaving and preparing the skin, we used 3M Red Dot electrodes to secure the leads and then two overlapping 20 cm strips of 2″ Kinesiology Tape (Theraband, Akron OH) layered over the entire device. Ten of 27 applications required complete reapplication due to unsatisfactory signal. The device was checked twice per day and four required reapplication 3–4 days into data collection because the tape detached. Failure of the tape occurred after bathing and dressing. Neither the participants nor the nursing staff expressed problems with the Actiheart. Actiheart units were cleaned by soaking overnight in Cidex OPA solution (Johnson&Johnson, Markham ON, Canada) followed by soak and rinse in tap water.

Discussion

By monitoring activity and HR among newly admitted stroke rehabilitation inpatients, we conclude that the patients spent most their time sedentary and the intensity and frequency of therapies offered did not reach recommended levels. Mapping of sedentary time demonstrated that, outside of PT and OT, there were few opportunities to engage in activity. With no association with disability or other patient-related factors, sedentary time was likely more attributable to institutional or program-related factors. Furthermore, blocks of uninterrupted sedentary time were on average 5.3 h long on weekdays and 6.8 h long on weekends; levels that will likely lead to deconditioning. Our findings point to three aspects of inpatient rehabilitation that could be addressed, (1) Breaking up long blocks of sedentary time, (2) Increasing the intensity of therapy sessions, and (3) Ensuring that patients receive recommended levels of therapy per week (15 sessions). The Actiheart unit along with an activity log could be useful in monitoring the effectiveness of structure and process changes.

Sedentary time and risk of physical deconditioning

Excessive sedentary time may in fact be putting patients at greater risk of developing physical deconditioning during inpatient rehabilitation. We found that patients in this rehabilitation unit were spending an alarming 86.6% of their awake time sedentary. Although we were the first to record sedentary time for 24 h a day, 7 days a week, this finding is in concordance with other stroke rehabilitation programs around the globe. For instance, Bernhardt et al. found that, during the therapeutic day (8 am–5 pm) patients spend >50% of their time resting in bed[12] while Tieges et al. reported that patients spent 81% of waking hours sedentary.[20] The high level of sedentary time also aligned with (ankle) accelerometry data from an acute stroke unit in which patients were sedentary about 94% over 3 monitoring days including sleep.[13] These findings are concerning as excessive sedentary time has known detrimental effects on the cardiorespiratory system. In just 20 days of bedrest, healthy young adults experienced a 28% reduction in mean maximal oxygen consumption (3.39–2.43L/min) and a 26% decrease in cardiac output.[15] This excessive sedentary time had a more detrimental impact on the cardiorespiratory system than 30 years of aging.[35] We show that, at least in this stroke center, stroke survivors' level of sedentary time was comparable to bedrest. Therefore, we could expect to see similar declines in cardiorespiratory fitness; greatly limiting performance of activities of daily living.[36] Fortunately, exemplary stroke programs exist in which patients are more engaged. For example, in a rehabilitation unit in the Netherlands, HR monitoring during 7 h workdays showed that 120 min/day was spent above 40% Heart Rate Reserve.[37] However, even in such a unit, individual PT and OT did not provide sufficient cardiorespiratory strain to improve fitness while group activities such as hydrotherapy, walking, and fitness did.[37] This finding suggests that activities provided outside of 1:1 PT and OT are useful in order to increase intensity and likely to also decrease sedentary time. Patients who have suffered a stroke typically have pre-existing risk factors for cardiovascular disease, such as high cholesterol, high blood pressure, overweight/obese, tobacco use, and lack of physical activity.[38] Therefore, these lifestyle factors, in addition to the detrimental cardiorespiratory effects of sedentary time during rehabilitation, are likely to substantially increase a patients' risk of suffering a second stroke or other vascular incident. In fact, a recent meta-analysis found that more than 10 h of sedentary time per day increases the risk of cardiovascular disease (hazard ratio = 1.08)[39]; our participants spent 12.75 h/day sedentary. It is possible that inpatient stroke care, structured similarly to the one described here (with primarily 1:1 sessions and few group activities), could actually be making patients worse in terms of cardiorespiratory fitness.

Breaking up sedentary time – whose role is it anyway?

It is the responsibility of the institutional structure, healthcare providers, program staff as well as patients themselves, and families to encourage and support activity.[40] We found that stroke survivors not only spent the majority of their time sedentary, but this time was clustered into large blocks (average > 5 h) with no activity breaks, particularly prevalent at mid-day (11:00–13:00) and in the evening (>15:00). Although functional disability has been previously associated with activity levels,[41] we found that even though the participants' functional ability likely improved over the course of rehabilitation, their time spent sedentary did not change. Similarly, Astrand et al. found no differences in activity between post-stroke acute and rehabilitation settings, even though the rehabilitation group had far greater functional ability.[9] Tieges et al. also reported that sedentary behavior was unchanged over the first year after stroke irrespective of functional ability.[20] In a review of 31 studies of inpatient rehabilitation delivery, Taylor et al. noted that therapy is usually provided 1:1 with very little activity outside of these sessions.[40] Furthermore, patients reported that they were bored. Taken together, these reports suggest that other factors related to the structure of hospital-based care, independent of functional ability, likely contribute to the abundance of sedentary time. In 2016, Astrand et al. suggested that the hospital environment and its structure and processes are risk-averse, preferring to situate patients around the bedside.[9] Surprisingly, stroke survivors perceive sedentary behavior to be normal and in fact, important, after stroke; reporting that they received those recommendations from physical therapists and other healthcare providers.[22] There seems to be a consistent culture surrounding rehabilitation that promotes rest and discourages activity that requires a paradigm shift.[40] As English et al. suggests, the practice of sedentary time begins early after stroke and healthcare providers must set activity expectations early on.[23] Several research groups have tested strategies to reduce sedentary time or increase intensity. Increasing the intensity of physical therapy improves functional outcomes,[42] but does not break up sedentary time. Adding evening and weekend physical therapy sessions, engaging nurses to promote activity and providing more formal group counseling all help to reduce sedentary time.[16,23,43] Enriching the environmental structure, such as adding communal areas for socializing and daily group activities, significantly reduces the amount of time patients' spend sedentary.[17] Many of these strategies have been known for some time yet conditions have changed little since MacKay-Lyons & Makrides measured stroke inpatient rehabilitation activity levels, some 15 years ago.[11] This suggests an urgent need for knowledge translation approaches.

Patients were not receiving best-practice recommended therapy

According to our findings, patients attending the inpatient rehabilitation unit were not receiving levels of task-specific practice recommended by best-practice guidelines. These guidelines state that "patients should receive at least 15 h of direct task specific therapy per week" (900 min of therapy a week).[44] However, we found that patients were only receiving an average of 519.6 min of therapy per week. Similarly, Bernhardt et al. in an acute stroke unit found that patients were only receiving 79.3 min of therapy in a day, or 396.5 min per week.[12] As reported by Clarke et al., most stroke patients in the UK also did not achieve recommended dose of therapy (45 min 5 days per week).[45] Not only are patients not receiving enough therapy, but the therapy they are receiving may not be intense enough to promote optimal recovery and benefit cardiorespiratory fitness. We found that only 4 of 19 participants reached 30–45% of heart rate reserve (HRR) during PT sessions and only 2 participants reached this HRR recommendation during OT sessions. These findings concur with those of MacKay-Lyons & Makrides reporting that PT and OT sessions were of low intensity and not adequate to induce metabolic stress.[11] Lower than recommended levels of therapy, the low-intensity nature of therapy and excessive sedentary time likely conspire to reduce the potential for recovery. Even if novel stroke interventions became available, such as brain stimulation, plasticity-promoting drugs, or stem cells, they would be introduced into what seems to be an impoverished, rather than enriched, environment.

Opportunities using continuous monitoring

By collecting HR and activity data to determine MET values, 24 h/day, 7 days/week, we were able to create a clearer picture of sedentary time in inpatient rehabilitation. Previous studies in rehabilitation have only included working hours (9 am–5 pm) and the typical workweek (Monday–Friday).[9,12,19] One study that took place in an acute stroke unit employed an accelerometer on the ankle 24hrs/day over three days.[13] Although the authors reported that 93.9% of time was spent sedentary, the estimate included sleeping time. The actual amount of sedentary time could have been much lower when sleeping time was removed. Heart rate monitoring such as that provided with Actiheart, permits identification of sleep and sleep patterns. By collecting data continuously, we show that patients are even more sedentary than we had previously thought when measuring the typical workweek. The Actiheart unit was acceptable by both patients and the nursing staff although it required removal of chest hair, a layer of flexible tape to ensure the device remained adhered for 7 days and frequent monitoring since several became detached. Patient monitoring using new technology such as GPS, activity and HR may be a useful tool in changing the typical rehabilitation environment and monitoring the effectiveness of knowledge translation strategies.

Limitations

Although we provide the first evidence of excessive sedentary time using continuous monitoring during stroke inpatient rehabilitation, the main limitation is the small sample size taken from only one institution. This 22-bed rehabilitation unit was typical of stroke rehabilitation units in Canada based on the Canadian Institute for Health Information National Rehabilitation Reporting System. It seems as though many rehabilitation units in the US, UK and Europe function similarly but there are notable exceptions.[37,40,45] We attempted to enroll every newly admitted patient over the three-month period however, only just over half of those eligible consented. We also attempted to collect data during the last week of admission, but only eight of the initial 19 participants were included. Half did not consent and half were discharged unexpectedly. It is possible that those individuals who refused to participate were also those who had very low levels of activity. Anecdotally, we observed that patients who were more engaged were more likely to participate which is typical of studies of physical activity[46]; so in fact, levels of sedentary time could be even higher than measured here.

Conclusion

Despite calls for highly-intensive stroke rehabilitation, there was excessive sedentary time and therapy sessions were less frequent and of lower intensity than recommended levels in this Canadian stroke rehabilitation unit. Stroke patients receiving inpatient rehabilitation spent over 86% of their time sedentary. Our data suggest that institutional structure of rehabilitation rather than patient-related factors contributed to sedentary time. These were all troublesome results, as intensity and frequency of therapy can have a positive impact on recovery. Our findings are similar to those reported beginning 15 years ago, suggesting that knowledge translation strategies are urgently needed.

Funding

This work was supported by the Canada Research Chairs Program (MP) [grant number 230457]; Canada Foundation for Innovation [grant number 33621]; Research and Development Corporation NL [grant number 5404-1699-105].

ORCID

John Charles Snow http://orcid.org/0000-0002-7638-4034
Maria Gehue http://orcid.org/0000-0001-5379-2214
Jason McCarthy http://orcid.org/0000-0003-0546-0076

References

1. Feigin VL, Forouzanfar MH, Krishnamurthi R, et al. Global and regional burden of stroke during 1990-2010: Findings from the global burden of disease study 2010. Lancet. 2014;383:245–255.
2. Dromerick AW, Lang CE, Birkenmeier RL, et al. Very early constraint-induced movement during stroke rehabilitation (VECTORS): A single-center RCT. Neurology. 2009;73:195–201.
3. Ploughman M, Corbett D. Can forced-use therapy be clinically applied after stroke? An exploratory randomized controlled trial. Arch Phys Med Rehabil. 2004;85:1417–1423.
4. Saposnik G, Cohen LG, Mamdani M, et al. Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): A randomised, multicentre, single-blind, controlled trial. Lancet Neurol. 2016;15:1019–1027.
5. Hubbard IJ, Parsons MW, Neilson C, Carey LM. Task-specific training: Evidence for and translation to clinical practice. Occup Ther Int. 2009;16:175–189.
6. Kelly LP, Devasahayam AJ, Chaves AR, et al. Intensifying functional task practice to meet aerobic training guidelines in stroke survivors. Front Physiol. 2017;8:809.
7. van de Port IG, Wevers L, Roelse H, van Kats L, Lindeman E, Kwakkel G. Cost-effectiveness of a structured progressive task-oriented circuit class training programme to enhance walking competency after stroke: The protocol of the FIT-Stroke trial. BMC Neurol. 2009;9:43.
8. Murphy TH, Corbett D. Plasticity during stroke recovery: From synapse to behaviour. Nat Rev Neurosci. 2009;10:861–872.
9. Astrand A, Saxin C, Sjoholm A, et al. Poststroke Physical activity levels no higher in rehabilitation than in the acute hospital. J Stroke Cerebrovasc Dis. 2016;25:938–945.
10. Lacroix J, Daviet JC, Borel B, Kammoun B, Salle JY, Mandigout S. Physical activity level among stroke patients hospitalized in a rehabilitation unit. PM R. 2016;8:97–104.
11. MacKay-Lyons MJ, Makrides L. Cardiovascular stress during a contemporary stroke rehabilitation program: Is the intensity adequate to induce a training effect? Arch Phys Med Rehab. 2002;83:1378–1383.
12. Bernhardt J, Dewey H, Thrift A, Donnan G. Inactive and alone: Physical activity within the first 14 days of acute stroke unit care. Stroke. 2004;35:1005–1009.
13. Mattlage AE, Redlin SA, Rippee MA, Abraham MG, Rymer MM, Billinger SA. Use of accelerometers to examine sedentary time on an acute stroke unit. J Neurol Phys Ther. 2015;39:166–171.
14. Sjoholm A, Skarin M, Churilov L, Nilsson M, Bernhardt J, Linden T. Sedentary behaviour and physical activity of people with stroke in rehabilitation hospitals. Stroke Res Treat. 2014;2014:591897.
15. Saltin B, Blomqvist G, Mitchell JH, Johnson RL Jr., Wildenthal K, Chapman CB. Response to exercise after bed rest and after training. Circulation. 1968;38:VII1–78.
16. Peiris CL, Shields N, Brusco NK, Watts JJ, Taylor NF. Additional Saturday rehabilitation improves functional independence and quality of life and reduces length of stay: A randomized controlled trial. BMC Med. 2013;11:c1718.
17. Rosbergen IC, Grimley RS, Hayward KS, et al. Embedding an enriched environment in an acute stroke unit increases activity in people with stroke: A controlled before-after pilot study. Clin Rehabil. 2017;269215517705181.
18. AVERT Trial Collaboration Group. Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): A randomised controlled trial. Lancet. 2015;386:46–55.
19. Gage WH, Zabjek KF, Sibley KM, Tang A, Brooks D, McIlroy WE. Ambulatory monitoring of activity levels of individuals in the sub-acute stage following stroke: A case series. J Neuroeng Rehabil. 2007;4:41.
20. Tieges Z, Mead G, Allerhand M, et al. Sedentary behavior in the first year after stroke: A longitudinal cohort study with objective measures. Arch Phys Med Rehabil. 2015;96:15–23.
21. Ezeugwu VE, Manns PJ. Sleep duration, sedentary behavior, physical activity, and quality of life after inpatient stroke rehabilitation. J Stroke Cerebrovasc Dis. 2017;26:2004–2012.
22. Ezeugwu VE, Garga N, Manns PJ. Reducing sedentary behaviour after stroke: perspectives of ambulatory individuals with stroke. Disabil Rehabil. 2017;39:2551–2558.
23. English C, Healy GN, Olds T, et al. Reducing sitting time after stroke: A phase II safety and feasibility randomized controlled trial. Arch Phys Med Rehabil. 2016;97:273–280.
24. Harris JE, Eng JJ, Miller WC, Dawson AS. A self-administered graded repetitive arm supplementary program (GRASP) improves arm function during inpatient stroke rehabilitation: A multi-site randomized controlled trial. Stroke. 2009;40:2123–2128.
25. Canadian Institutes for Health Information (CIHI). NRS Function Scores of Inpatient Rehabilitation Clients 2016. https://apps.cihi.ca/mstrapp/asp/Main.aspx?Server=apmstrextprd_i&project=Quick%20Stats&uid=pce_pub_en&pwd=&evt=2048001&visualizationMode=0&documentID=E127EF8C43C40296932756A953A75076. Accessed March 18, 2018.
26. Vanroy C, Vanlandewijck Y, Cras P, et al. Is a coded physical activity diary valid for assessing physical activity level and energy expenditure in stroke patients? PLoS ONE. 2014;9:e98735.
27. Kasner SE, Chalela JA, Luciano JM, et al. Reliability and validity of estimating the NIH stroke scale score from medical records. Stroke. 1999;30:1534–1537.
28. Sulter G, Steen C, De Keyser J. Use of the barthel index and modified rankin scale in acute stroke trials. Stroke. 1999;30:1538–1541.
29. Granger CV, Dewis LS, Peters NC, Sherwood CC, Barrett JE. Stroke rehabilitation: Analysis of repeated Barthel index measures. Arch Phys Med Rehabil. 1979;60:14–17.
30. Tawalbeh Li, Ahmad MM. Personal resource questionnaire: A systematic review. The journal of nursing research : JNR. 2013;21:170–177.
31. Spinhoven P, Ormel J, Sloekers PP, Kempen GI, Speckens AE, Van Hemert AM. A validation study of the hospital anxiety and depression scale (HADS) in different groups of Dutch subjects. Psychological Medicine. 1997;27:363–370.
32. Sagen U, Vik TG, Moum T, Morland T, Finset A, Dammen T. Screening for anxiety and depression after stroke: Comparison of the hospital anxiety and depression scale and the Montgomery and Asberg depression rating scale. J Psychosom Res. 2009;67:325–332.
33. Verschuren O, de Haan F, Mead G, Fengler B, Visser-Meily A. Characterizing energy expenditure during sedentary behavior after stroke. Arch Phys Med Rehabil. 2016;97:232–237.

34. Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the reporting of observational studies in epidemiology (STROBE): Explanation and elaboration. Epidemiology. 2007;18:805–835.
35. McGuire DK, Levine BD, Williamson JW, et al. A 30-year follow-up of the Dallas Bedrest and training study: II. Effect of age on cardiovascular adaptation to exercise training. Circulation. 2001;104:1358–1366.
36. Ivey FM, Macko RF, Ryan AS, Hafer-Macko CE. Cardiovascular health and fitness after stroke. Top Stroke Rehabil. 2005;12:1–16.
37. Koopman AD, Eken MM, van Bezeij T, Valent LJ, Houdijk H. Does clinical rehabilitation impose sufficient cardiorespiratory strain to improve aerobic fitness? J Rehabil Med. 2013;45:92–98.
38. Jokinen E. Obesity and cardiovascular disease. Minerva Pediatr. 2015;67:25–32.
39. Pandey A, Salahuddin U, Garg S, et al. Continuous dose-response association between sedentary time and risk for cardiovascular disease: A meta-analysis. JAMA Cardiol. 2016;1:575–583.
40. Taylor E, McKevitt C, Jones F. Factors shaping the delivery of acute inpatient stroke therapy: A narrative synthesis. J Rehabil Med. 2015;47:107–119.
41. Janssen H, Ada L, Bernhardt J, et al. Physical, cognitive and social activity levels of stroke patients undergoing rehabilitation within a mixed rehabilitation unit. Clin Rehabil. 2014;28:91–101.
42. Chan B. Effect of increased intensity of physiotherapy on patient outcomes after stroke: An economic literature review and cost-effectiveness analysis. Ont Health Technol Assess Ser. 2015;15:1–43.
43. van de Port IG, Valkenet K, Schuurmans M, Visser-Meily JM. How to increase activity level in the acute phase after stroke. J Clin Nurs. 2012;21:3574–3578.
44. Hebert D, Lindsay MP, McIntyre A, et al. Canadian stroke best practice recommendations: Stroke rehabilitation practice guidelines, update 2015. Int J Stroke. 2016;11:459–484.
45. Clarke DJ, Tyson S, Rodgers H, et al. Why do patients with stroke not receive the recommended amount of active therapy (ReAcT)? Study protocol for a multisite case study investigation. BMJ Open. 2015;5:e008443.
46. Bravata DM, Smith-Spangler C, Sundaram V, et al. Using pedometers to increase physical activity and improve health: A systematic review. JAMA. 2007;298:2296–2304.