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Sitting time and physical activity after stroke. Physical ability is only part of the story.

Abstract

Background

Understanding factors that influence the amount of time people with stroke spend sitting and being active is important to inform the development of targeted interventions.

Objective

To explore the physical, cognitive and psychosocial factors associated with daily sitting time and physical activity in people with stroke.

Method

Secondary analysis of an observational study (n=50, mean age 67.2 ± 11.6 years, 33 men) of adults at least six months post-stroke. Activity monitor data were collected via a seven day, continuous wear (24 hours/ day) protocol. Sitting time (total, and prolonged [time in bouts of ≥30mins]) was measured with an activPAL3 activity monitor. A hip-worn Actigraph GT3X+ accelerometer was used to measure moderate-to-vigorous-intensity physical activity (MVPA) time. Univariate analyses examined relationships of stroke severity (National Institutes of Health Stroke Scale), physical (walking speed, Stroke Impact Scale physical domain score), cognitive (Montreal Cognitive Assessment) and psychosocial factors (living arrangement, Stroke Impact Scale emotional domain score) with sitting time, prolonged sitting time and MVPA.

Results

Self-reported physical function and walking speed were negatively associated with total sitting time (r=-0.354, p=0.022 and r=-0.361, p=0.011 respectively) and prolonged sitting time (r= -0.5, p = 0.001 and -0.45, p = 0.001 respectively), and positively associated with MVPA (r = 0.469, p = 0.002 and 0.431, p = 0.003, respectively).

Conclusions

Physical factors such as walking ability may influence sitting and activity time in people with stroke, yet much of the variance in daily sitting time remains unexplained. Large prospective studies are required to understand the drivers of activity and sitting time.

Keywords

stroke, sedentary behaviors, sitting time, physical activity, objective activity monitoring

Introduction

The prevalence rates of stroke are increasing globally[1, 2] and an estimated 43% of stroke survivors will suffer a recurrent stroke.[3] Time spent in physical activity, particularly activity of at least moderate intensity, and time spent in sedentary behaviors, are both independent risk factors for cardiovascular disease.[4, 5] Participation in adequate moderate-to-vigorous-intensity physical activity (MVPA) is vital in the prevention of chronic disease such as type 2 diabetes, cardiovascular disease and stroke.[5-7] Current public health guidelines recommend that all adults engage in at least 150 minutes per week of at least moderate-intensity physical activity,[8] and guidelines for people with stroke include the same recommendations.[6] More recently, the duration of time spent in sedentary behaviors has been associated with cardiovascular disease risk, type 2 diabetes, obesity, breast and colon cancer, and cardiovascular and all-cause mortality,[5, 9, 10] independent of MVPA.[11, 12] Sedentary behaviors are defined as waking time behaviors characterized by low energy expenditure in sitting or reclining postures.[13] Prolonged bouts of sitting, typically defined as greater than 30 minutes of uninterrupted sitting[14] may be particularly deleterious.[4, 15]

Physical activity levels in people with stroke have been shown to be consistently lower when compared with their healthy peers, with stroke survivors accumulating less than half the daily steps.[16] However, there is a paucity of literature describing how much time people with stroke spend sitting and in MVPA each day.[16] A recent systematic review[16] identified only three studies in which time spent in MVPA in people with stroke was specifically reported.[17-19] In these studies, measures of step cadence[17-19] or heart rate[17] were used to measure intensity of activity. There were no papers identified that used a postural-based objective measure to specifically measure time sitting and/or lying down. We recently conducted an observational study examining physical activity and sedentary behavior patterns in people living at home after stroke, compared to age-matched healthy control participants .[20] We found that people with stroke were both highly sedentary (spending almost 11 hours a day, or 75% of waking hours sitting down) and had very low physical activity levels (spending on average less than 5 minutes a day in MVPA).

In previous research, physical factors such as walking speed,[17, 20-25] walking capacity,[22,23,26-2821, 22, 25-27] balance[19, 24, 25, 27, 28] and physical fitness[17, 19, 29-31] have been found to be positively associated with daily step counts in people with stroke. This suggests that the degree of physical impairment after stroke may be an important factor driving levels of physical activity. On the other hand, depression[17, 32] and poorer quality of life[26] have been negatively associated with daily step counts in this population. To date, we do not know what factors may influence sitting time, prolonged sitting time or time spent in MVPA in people with stroke.

Understanding factors that may influence the amount of time people with stroke spend sitting and in physical activity of at least moderate intensity is important if we are to develop effective interventions to address inactivity in this population. Therefore, the aim of this exploratory study was to examine the physical, cognitive and psychosocial factors associated with daily sitting time, including sitting time accrued in prolonged (≥30 minutes), unbroken bouts, and with time spent in activities of at least moderate intensity in people with stroke. As this was an exploratory study we did not have any pre-specified hypotheses.

Methods

Study Design

This was an exploratory, secondary analysis of a cross-sectional observational study. The primary outcomes of the observational study are detailed elsewhere .[20] Ethical approval was gained from the University Research Ethics Committee (protocol number 0000030464), and all participants provided written, informed consent.

Participants

As we were interested in the factors influencing daily, habitual sitting time and physical activity, we specifically targeted people living at home after stroke. People with stroke were eligible to participate if they were at least six months post-stroke (ischemic or hemorrhagic), had returned to living at home for at least two months since their most recent stroke, had residual gait deficits, but were able to walk independently around the house with or without walking aids and had sufficient cognitive ability to provide informed consent. Those people who self-identified as having normal walking ability were excluded. Participants were recruited from community stroke exercise classes, physiotherapy outpatient services, social media and databases of people discharged from rehabilitation. Potential participants were screened via a telephone call, and their eligibility (in particular their ability to walk independently) was confirmed at the first face-to-face assessment.

Protocol

At baseline, all participants undertook a face-to-face assessment in their own home followed by seven days of objective activity monitoring. Data collected at baseline included height, weight and waist circumference, stroke-related factors (date of stroke, type of stroke [Oxfordshire Stroke Classification],[34] stroke severity [National Institutes of Health Stroke Scale (NIHSS)],[35] stroke-related function (Stroke Impact Scale (SIS) physical and emotional domain scores),[36] and cognitive ability (Montreal Cognitive Assessment [MoCA]).[37] Walking ability was further assessed by measuring comfortable walking speed (using a stop-watch over the middle 5m of a 9m walkway)[38] and asking about usual walking aid use. Participants were asked if they lived alone or with a spouse or other person. They were also asked if they needed any assistance with personal tasks (showering, dressing, grooming) on a daily basis, and on the basis of this were rated as ‘independent’, or ‘requiring assistance’. Participants were then fitted with the activity monitors (described below) and were instructed to wear them for 24 hours a day for the next seven days. Participants were also asked to keep a daily diary of sleep and wake times and times when the monitor(s) were removed.

Outcome Measures

Sitting time was measured using the activPAL3 activity monitor (PAL Technologies Ltd) [a]. This small unit (measuring 5.0 x 3.5 x 0.7 cm and weighing 20 g) contains a tri-axial accelerometer and inclinometer and is worn on the anterior thigh. It provides date and time-stamped information on sitting/lying, 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 activPAL directly measures posture. It has been shown to be highly accurate in classifying sitting and standing activities in people with stroke.[39] The monitor was waterproofed, attached to the non-paretic thigh and worn continuously (24 hours per day) for seven days.

Moderate- to vigorous-intensity physical was measured using the Actigraph GT3X+ tri-axial accelerometer (Actigraph Penascola FL)[b], worn on an elasticized waist band in the mid-axillary line above the non-paretic hip. The accelerometer was worn for seven days, 24 hours a day, removed only for showering and water-based activities. This device has been shown to discriminate well between different movement speeds, ranging from slow walking (0.89 m/s) to moderate running (2.7 m/s).[40] Participants also wore a Sensewear multisensor array arm band (BodyMedia Inc Pittsburgh PA)[c] around the non-hemiparetic upper arm. In this study, Sensewear data were used only to assist in the identification of periods when the monitor was not worn (non-wear periods) as outlined below.

Data Processing

Sitting time The activPAL3 data were downloaded via manufacturer's software (activPAL3 version 7.1.18) with event files and 15 second epoch files saved as Excel spreadsheets. Sleep/wake times and monitor non-wear time from participant diaries were entered into a

Microsoft Access database, with estimated sleep/wake times (from the event files) used if diary data were missing. A custom built SAS program linked participant diary data with activPAL3 event file data to extract data relating to waking hours only (excluding periods of non-wear as reported in diaries). These daily sleep/wake times were also applied to the Actigraph data.

Wear time validation (Actigraph) As the Actigraph and Sensewear arm bands had to be removed for any water-based activities, this increased the risk of participants forgetting to put the monitors back on, making identification of wear time important. The Sensewear arm band only collects data when the sensors are in contact with the skin. This allows periods of non-wear to be easily identified. We checked the participants' sleep/wake logs and found that participants always reported identical removal periods for both monitors. Therefore, we removed all Sensewear-detected periods of non-wear time from the Actigraph data. Any days with less than four hours of wear time for the Actigraph monitor were excluded from the dataset.. Participants with less than three days of valid Actigraph data were excluded from further analyses.

Physical activity Actigraph data were processed using the Actilife software version 6.3.2. Custom filters were used to identify wake time periods for each day of data for each participant. We used Freedson's cut-points to classify physical activity intensity as light (100-1951 counts per minute [cpm]), or moderate to vigorous (MVPA, ≥1952 cpm).[41] While Freedson's equations were validated in younger adults, they are the most commonly used cut points for classifying activity of older adults.[42]

Data Analyses

As this was an exploratory secondary analysis of an existing dataset, no specific sample size calculations were conducted. Our dependent variables were total daily sitting time, total daily prolonged sitting time (≥ 30 minutes of uninterrupted sitting) and total daily time in MVPA.

Our independent variables were walking speed, self-reported physical function (SIS physical domain score), stroke severity (NIHSS score), living arrangement (alone or with spouse/other), degree of independence with activities of daily living (ADLs), time since stroke, self-reported emotional state (SIS emotional domain), cognitive function (MoCA score) and body mass index (kg/m^{-2}). We used univariate analyses and descriptive statistics to examine the relationships between independent and dependent variables. Linear multiple regression analyses were used to examine the relative influence of each of the factors on total sitting time, time accrued in prolonged sitting and time in MVPA. We adjusted the analyses relating to sitting time for the time spent awake each day (waking hours). All analyses were conducted using IBM SPSS version 21, with significance set at $p<0.05$.

Results

Fifty people with stroke (67.2 ± 11.6 years) were recruited. Table 1 presents the demographic characteristics of the sample. Four people had less than four days of valid Actigraph data, and one person did not wear the activPAL monitor due to the equipment being unavailable. Therefore, valid activPAL and Actigraph data were available for n=49 (98%) and n=46 (92%) participants respectively.

Total daily sitting time

Both SIS physical domain scores and walking speed were significantly correlated with total daily sitting time (r=-0.354, p=0.022 and r=-0.361, p=0.011 respectively), albeit weakly. Participants who were independent in all ADLs had a lower average daily sitting time than those who required some assistance (10.4 ± 1.7 hrs/day vs 11.1 ±2.0 hrs/day). Entering these factors (walking speed, SIS physical domain scores and degree of independence) into a multiple regression equation explained only 6.8% of the variance in total daily sitting time (Table 3). Adjusting this analysis to include waking hours strengthened the model, explaining

29.6% of the variance (p=0.002) suggesting that total daily sitting time is strongly influenced by waking hours.

Time spent in prolonged sitting

As with total daily sitting time, both SIS physical domain scores and walking speed were significantly negatively associated with time spent in prolonged sitting (r=-0.5, p=0.001 and -0.45, p = 0.001 respectively). In addition, participants who needed some help with ADLs, spent on average 1.5 hours longer each day in prolonged sitting compared to those who did not require assistance. Stroke severity appeared to also influence prolonged sitting time, with participants with moderate symptoms spending on average 1.4 hours more time in prolonged sitting per day compared to those with no symptoms (Table 2). Entering only walking speed and SIS physical domain scores into a regression model significantly predicted 22.2% of variance in prolonged sitting time, (*p*=0.003) although only the SIS physical domain score was significant within the regression equation (Table 3). Adding in NIHSS categories and level of independence in ADLs strengthened the model (explaining 28.2% of the variance, *p*=0.001). Adjusting the analyses for waking hours only slightly strengthened the model (explaining 30.0% of the variance, p=0.002).

Daily time in MVPA

Factors correlated with MVPA at a univariate level were walking speed (0.431, p=0.003) and SIS physical (r = 0.469, p=0.002). Participants who were independent in ADLs spent more time in MVPA per day (8.1 ± 8.8mins) vs those who needed daily help (2.5 ± 4.4mins). NIHSS categories also seemed to influence time in MVPA (Table 2). Entering only walking speed and SIS physical domain scores into the regression model significantly predicted 21% of the variance in MVPA, (*p*=0.005) although the individual factors within the regression equation were not significant (Table 3). Adding in NIHSS categories and level of independence in ADLs weakened the model (19.4% variance, *p*=0.02).

Discussion

Very little is known about the factors associated with the amount of time people with stroke spend sitting each day, and in physical activity of at least moderate intensity. This is in spite of the fact that inadequate levels of physical activity of at least moderate intensity is a significant risk factor for first and recurrent stroke,[1, 7] and high sitting time is an independent risk factor for both all-cause and cardiovascular disease related mortality.[4, 5, 10] This exploratory study provides early insights into the influence of physical and stroke related factors on daily sitting time and MVPA. We found that greater self-reported physical disability and slower walking speed, were associated with more time spent sitting, and in particular more time spent in prolonged bouts of sitting, as well as less time in MVPA. Not surprisingly, stroke severity was also associated with less time spent in MVPA and more time spent in prolonged bouts of sitting.

Previous studies investigating physical activity in people with stroke have found physical factors such as walking speed, stair climbing ability and balance to be associated with increased daily step counts.[17, 20-25, 27, 28] Our findings suggest that walking speed and self-reported physical function may also impact the amount of time spent in physical activity of at least moderate intensity. Given that most healthy adults sit for very long periods each day[4] and most do not meet exercise guidelines,[43] it is clear that walking ability and physical function are not the only factors influencing physical activity. Furthermore, it is important to remember that we cannot infer causation from correlational relationships. However, it is possible that reducing physical disability, in particular increasing walking ability in people after stroke may have a positive influence on sitting time and physical activity levels. This hypothesis requires testing in clinical trials.

While previous studies have reported negative associations between emotional and cognitive factors and physical activity in people with stroke,[17, 25, 32] these were not significantly predictive factors of either sitting time or physical activity in our cohort. However, the majority of our participants (n=39, 78%) had scores above the cut-off for cognitive impairment on the MoCA,[37] and emotional domain scores on the SIS in this group were relatively high.

Given the emerging evidence of the cause and effect relationship between prolonged sitting and metabolic health, it is interesting that we found that physical factors were more strongly associated with time spent in prolonged sitting than they were with total daily sitting time. Previous experimental work has shown that prolonged bouts of sitting are significantly associated with harmful changes in whole body insulin sensitivity, independent of energy intake.[44,45] Furthermore, breaking up prolonged sitting time with periods of light physical activity has been shown to reduce post-prandial blood glucose by almost a quarter.[44] Further work is required to determine whether breaking up periods of prolonged sitting with short bouts of light intensity activity has health benefits for people with stroke. Reducing prolonged periods of sitting may be a more appropriate intervention target than aiming to reduce sitting time as a whole.

Strengths and Limitations

This study involved a secondary analysis of an observational dataset including people at least six months post-stroke, living independently in metropolitan areas, and able to walk independently. Therefore, the findings from this study are only generalizable to people with stroke living in similar context, of a similar age and with similar levels of physical functioning to those included in the study. It is likely that people with stroke not living in the community, and requiring assistance with walking may have different predictors to sitting time and physical activity. As this was an exploratory, secondary analysis of an existing dataset, we were limited by the measures collected in the original studies. Other factors, including co-morbidities, fear of falling, pre-morbid physical fitness and attitudes to exercise may also influence sitting time and physical activity levels.

The main methodological strength of this study was the use of high precision, valid objective activity monitors to measure sitting time, patterns of accumulation of sitting time and time spent in moderate-to vigorous intensity physical activity.

Finally, there is conjecture in the literature around what constitutes a 'prolonged' bout of sitting. We used the definition of greater than or equal to 30 minutes, as it is the most commonly used definition in clinical trials.[14, 33] However, laboratory based studies have shown that breaking up sitting time with short bouts of light intensity activity every 20 minutes is associated with lower post-prandial glucose and insulin levels.[4434] It is possible that different criteria for determining a 'prolonged bout' of sitting may have impacted the results in the current study.

Conclusion

Physical factors such as walking ability appear to have some influence of sitting and activity time in people with stroke, yet much of the variance in daily sitting time remains unexplained. Further large prospective studies are required to understand the drivers of activity and sitting time to develop effective intervention strategies.

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: 245-54.
2. Heidenreich PA, Trogdon JG, Khavjou OA, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*, 2011. 123: 933-44.
3. Hardie K, Hankey GJ, Jamrozik K, et al. Ten-year risk of first recurrent stroke and disability after first-ever stroke in the Perth Community Stroke Study. *Stroke*, 2004. 35: 731-5.
4. Dunstan DW, Howard B, Healy GN, et al. Too much sitting--a health hazard. *Diabetes Res Clin Pract*, 2012. 97: 368-76.
5. Tremblay MS, Colley RC, Saunders TJ, et al. Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*, 2010. 35: 725-40.
6. Billinger SA, Arena R, Bernhardt J, et al. Physical activity and exercise recommendations for stroke survivors: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*, 2014. 45: 2532-53.
7. McDonnell MN, Hillier SL, Hooker SP, et al. Physical activity frequency and risk of incident stroke in a national US study of blacks and whites. *Stroke*, 2013. 44: 2519-24.
8. Health AGDo. *Australia's Physical Activity and Sedentary Behaviour Guidelines*. [cited 2014 19th May]; Available from: http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines#apaadult.

9. Beunza JJ, Martinez-Gonzalez MA, Ebrahim S, et al. Sedentary behaviors and the risk of incident hypertension: the SUN Cohort. *Am J Hypertens*, 2007. 20: 1156-62.
10. Stamatakis E, Hamer M, and Dunstan DW. Screen-based entertainment time, all-cause mortality, and cardiovascular events: population-based study with ongoing mortality and hospital events follow-up. *J Am Coll Cardiol*, 2011. 57: 292-9.
11. Healy GN, Matthews CE, Dunstan DW, et al. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J*, 2011. 32: 590-7.
12. Henson J, Yates T, Biddle SJ, et al. Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. *Diabetologia*, 2013. 56: 1012-20.
13. Network SBR. Letter to the Editor: Standardized use of the terms "sedentary" and "sedentary behaviours". *Applied Physiology, Nutrition and Metabolism*, 2012. 37: 540-42.
14. Healy GN, Eakin EG, Lamontagne AD, et al. Reducing sitting time in office workers: short-term efficacy of a multicomponent intervention. *Prev Med*, 2013. 57: 43-8.
15. Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care*, 2008. 31: 661-6.
16. English C, Manns PJ, Tucak C, et al. Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. *Phys Ther*, 2014. 94: 185-96.
17. Baert I, Feys H, Daly D, et al. Are patients 1 year post-stroke active enough to improve their physical health? *Disabil Rehabil*, 2012. 34: 574-80.
18. Manns PJ and Baldwin E. Ambulatory activity of stroke survivors: measurement options for dose, intensity, and variability of activity. *Stroke (00392499)*, 2009. 40: 864-867.

19. Michael K and Macko RF. Ambulatory activity intensity profiles, fitness, and fatigue in chronic stroke. *Top Stroke Rehabil*, 2007. 14: 5-12.

20. Roos MA, Rudolph KS, and Reisman DS. The structure of walking activity in people after stroke compared with older adults without disability: a cross-sectional study. *Physical Therapy*, 2012. 92 (9): 1141-1147.

21. Zalewski KR and Dvorak L. Barriers to physical activity between adults with stroke and their care partners. *Topics in Stroke Rehabilitation*, 2011. 18 Suppl 1: 666-75.

22. Alzahrani MA, Dean CM, and Ada L. Ability to negotiate stairs predicts free-living physical activity in community-dwelling people with stroke: an observational study. *Australian Journal of Physiotherapy*, 2009. 55: 277-81.

23. Bowden MG, Balasubramanian CK, Behrman AL, et al. Validation of a speed-based classification system using quantitative measures of walking performance poststroke. *Neurorehabil Neural Repair*, 2008. 22: 672-5.

24. Michael K, Allen J, and Macko R. Reduced ambulatory activity after stroke: the role of balance, gait, and cardiovascular fitness. *Archives of Physical Medicine and Rehabilitation*, 2005. 86: 1552-6.

25. Tiedemann A, Sherrington C, and Lord SR. Predictors of exercise adherence in older people living in retirement villages. *Prev Med*, 2011. 52: 480-1.

26. Fulk GD, Reynolds C, Mondal S, et al. Predicting home and community walking activity in people with stroke. *Arch Phys Med Rehabil*, 2010. 91: 1582-6.

27. Rand D, Eng JJ, Tang PF, et al. Daily physical activity and its contribution to the health-related quality of life of ambulatory individuals with chronic stroke. *Health Qual Life Outcomes*, 2010. 8: 80.

28. Michael KM, Allen JK, and Macko RF. Fatigue after stroke: relationship to mobility, fitness, ambulatory activity, social support, and falls efficacy. *Rehabil Nurs*, 2006. 31: 210-7.

29. Katoh J, Murakami M, Hirayama M, et al. Correlation of pedometric measurement of daily physical activity with exercise endurance by oxygen uptake kinetics in ambulatory stroke patients. *Journal of Physical Therapy Science*, 2002. 14: 77-80.

30. Manns PJ, Tomczak CR, Jelani A, et al. Oxygen uptake kinetics: associations with ambulatory activity and physical functional performance in stroke survivors. *J Rehabil Med*, 2010. 42: 259-64.

31. Resnick B, Michael K, Shaughnessy M, et al. Inflated perceptions of physical activity after stroke: pairing self-report with physiologic measures. *J Phys Act Health*, 2008. 5: 308-18.

32. Robinson CA, Shumway-Cook A, Ciol MA, et al. Participation in community walking following stroke: subjective versus objective measures and the impact of personal factors. *Physical Therapy*, 2011. 91: 1865-76.

33. Peddie MC, Bone JL, Rehrer NJ, et al. Breaking prolonged sitting reduces postprandial glycemia in healthy, normal-weight adults: a randomized crossover trial. *Am J Clin Nutr*, 2013. 98: 358-66.

34. Dunstan DW, Kingwell BA, Larsen R, et al. Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care*, 2012. 35: 976-83.

Table 1. Participant demographic characteristics

Characteristic	Mean (SD) or n(%)
Age (years)	67.20 (11.59)
Sex M:F	33:17
BMI (kg/m^2)	29.14 (4.53)
Waist circumference (cm)	99.89 (15.81)
Type stroke n (%)	
TACI	8 (16%)
PACI	16 (32%)
LACI	9 (18%)
POCI	1 (2%)
Hemorrhage	14 (28%)
Unknown	2 (4%)
Severity of stroke (NIHSS) n (%)	No symptoms (score 0): 8 (16%) mild (score 1-4): 25 (50%) moderate (score 5-15): 16 (32%) moderate to severe (score 16-20): 1 (2%)
Time since stroke (years) mean (SD)	3.89 (9.32) range 0.20 to 65.00*
Walking speed (m/s)	0.83 (0.41)
Stroke Impact Scale (score)	
Physical domain (0-100)	61.8 (21.1)
Emotional domain (0-100)	71.2 (18.5)

BMI = body mass index, TACI = total anterior circulation infarct, PACI= partial anterior circulation infarct, LACI= lacunar infarcts, POCI=posterior circulation infarcts
*one participant had a childhood stroke

Table 2. Factors influencing sitting time – univariate analyses

Factor	**Correlation with total sitting time, or mean (SD) of total sitting time (hours/day)**	**Correlation with prolonged sitting time, or mean (SD) of prolonged sitting time (hours/day)**	**Correlation with time in MVPA, or mean (SD) of time in MVPA (mins/day)**
SIS Physical domain score	**r = -0.354*, p=0.022**	**r = -0.50*, p=0.001**	**r = 0.469, p=0.002**
NIHSS categories			
no symptoms	10.9 (1.5)	**6.4 (2.1)**	**11.9 (13.0)**
mild	10.6 (2.3)	**7.0 (2.8)**	**5.0 (5.6)**
moderate	11.0 (1.4)	**7.8 (2.6)**	**3.0 (5.4)**
Living arrangement			
alone	10.8 (2.5)	6.9 (3.3)	3.2 (3.8)
with spouse	10.7 (1.7)	7.2 (2.4)	6.4 (8.4)
Independence			
independent with all ADLs	10.4 (1.7)	**6.5 (2.1)**	**8.1 (8.8)**
help with some ADLs	11.1 (2.0)	**8.0 (3.0)**	**2.5 (4.4)**
Years since stroke	r = -0.138, p=0.343	r = -0.114, p=0.436	r = -0.053, p=0.725
walking speed	**r = -0.361, p=0.011**	**r = -0.454, p=0.001**	**r = 0.431, p=0.003**
SIS emotional domain	r = 0.170, p=0.269	r = 0.083, p=0.591	r = 0.015, p=0.926

MoCA	r = 0.153, p=0.3	r = -0.006, p=0.970	r = 0.252, p=0.095
BMI	r = 0.124, p=0.397	r = 0.039, p=0.801	r = -0.169, p = 0.262

SIS = stroke impact scale, ADLs = activities of daily living, NIHSS = National Institutes of Stroke Severity Scale, MVPA = moderate to vigorous physical activity

Table 3. Factors influencing sitting time – multivariate analyses

Dependent variable	**Independent variable**	**Unstandardized ß (SE)**	**Standardized ß**	**p value**
Total sitting time	walking speed	-0.668 (0.972)	-0.141	0.496
	SIS – physical	-0.023 (0.021)	-0.251	0.264
	independence in ADLs	-0.051 (0.739)	0.013	0.945
Prolonged sitting time	walking speed	-0.766 (1.215)	-0.117	0.532
	SIS – physical	-0.055 (0.024)	-0.424	0.028
MVPA	walking speed	-1.049 (1.175)	-0.160	0.318
	SIS – physical	-0.073 (0.025)	-0.571	**0.005**
	NIHSS	-1.265 (0.612)	-0.327	**0.046**

SIS = stroke impact scale, ADLs = activities of daily living, NIHSS = National Institutes of Stroke Severity Scale, MVPA = moderate to vigorous physical activity

TSR119 “Sitting time and physical activity after stroke. Physical ability is only part of the story.”

Reviewer comments	**Response**
Reviewer #2: Participants: Authors mention that they excluded participants who self-identified as having no deficits in lower limb strength. It is not clear to what a valid reason or this would be. How many participants were excluded and why? I think including these participants would have further strengthened the results. I would mention this as a limitation.	Previous research has found an association between daily step counts and factors relating to physical disability (walking ability, balance, physical fitness) in people after stroke. For this reason we hypothesised that physical factors would also be related to high sitting time in this group, and therefore specifically recruited people with some degree of difficulty walking. This justification has been highlighted in the introduction by adding the following sentence: *“This suggests that degree of physical impairment after stroke may be an important factor driving levels of physical activity.” (page 4)* The methods have also been updated to reflect that people were excluded if they had normal walking ability (self-identified). We have updated the limitations section to read: *”Therefore, the findings from this study are only generalizable to people with stroke living in similar context, of a similar age and with similar levels of physical functioning to those included in the study.” (page 12)*

Authors mention that "data from days with less than 4hours of wear time were excluded". Please elaborate on this. Were the subjects removed from the data analyses or just the data from that particular day? What was the reason for non-adherence? How many data points were removed?	This been clarified in the data processing section of the methods which now reads: *“Any days with less than four hours of wear time for the Actigraph monitor were excluded from the dataset. Participants with less than three days of valid Actigraph data were excluded from further analyses.” (page 7)* We have also the following statement to the first paragraph of the results section: *“Four people had less than four days of valid Actigraph data, and one person did not wear the activPAL monitor due to the equipment being unavailable.” (page 8)*
It is not clear if the sample population had other comorbidities. It would be helpful to have some information regarding this and how it affected sitting time.	We did not collect specific data on co-morbidities. This limitation has been added to the limitations section of the discussion: *“As this was an exploratory, secondary analysis of an existing dataset, we were limited by the measures collected in the original studies. Other factors, including co-morbidities, fear of falling, pre-morbid physical fitness and attitudes to exercise may also influence sitting time and physical activity levels.” (page 12)*

The sample tested in this study leans towards an older population (average age 67 years). This will affect the generalizability of the study. This should also be included in the limitations.	The statement around generalizability of the study findings has been updated to include age. It now reads: *”Therefore, the findings from this study are only generalizable to people with stroke living in similar context, of a similar age and with similar levels of physical functioning to those included in the study.” (page 12)*
Reviewer #3: Manuscript overview/General comments: Introduction 1. Authors should consider emphasizing the relevant literature regarding the kinesiophobia and physical activity in stroke survivors. How is this relevant to the authors' interest?	Kinesiphobia is a term most often used in relation to fear of movement in the context of chronic pain states. In relation to people after stroke, fear of falling is more relevant, and may influence sitting time and physical activity levels. We did not have a measure of fear of falling in our study. This limitation has been added to the discussion: *“Other factors, including co-morbidities, fear of falling, pre-morbid physical fitness and attitudes to exercise may also influence sitting time and physical activity levels.” (page 12)*
2. Consider including any prespecified hypotheses.	As this was an exploratory study we did not have any pre-specified hypotheses. This has been clearly stated at the end of the introduction (page 4).
3. A specific justification is missing. Authors should clarify their	The following justification was stated in the 3rd paragraph of the

motivation for carrying out this study, and then highlight the potential importance of the findings to the field.	introduction: *"Understanding factors that may influence the amount of time people with stroke spend sitting and in physical activity of at least moderate intensity is important if we are to develop effective interventions to address inactivity in this population." (page 4)* This sentence now appears immediately before the aim of the study. The following sentence in the discussion highlights the potential importance of the findings to the field: *"… it is important to remember that we cannot infer causation from correlational relationships. However, it is possible that reducing physical disability, in particular increasing walking ability in people after stroke may have a positive influence on sitting time and physical activity levels. This hypothesis requires testing in clinical trials." (page 11)*
METHODS 1. Consider to include exclusion criteria. How was the exclusion criteria confirmed? What tests and who performed these test on subjects to establish the exclusion criteria? Who performed the assessments?	The inclusion and exclusion criteria are stated under the subheading of 'participants'. To clarify the process of determining the eligibility of potential participants, the following sentence has been added: *"Potential participants were screened via a telephone call, and their eligibility (in particular their ability to walk independently) was*

	confirmed at the first face to face assessment." (page 5)
2.The author should include a sample size calculation	The following clarifying statement has been added to the data analysis section of the methods: *"As this was an exploratory secondary analysis of an existing dataset, no specific sample size calculations were conducted." (page 8)*
3. Author should give explanation why they interested in chronic stroke survivors (6 months post stroke). What's the rational to focus on chronic stroke?	As we were interested in the factors influencing daily, habitual sitting time and physical activity, we specifically targeted people later after stroke who were living at home. Compared to people earlier after stroke, or those in hospital or residential aged care settings, this group of people are more likely to have relatively stable levels of physical ability and have the ability to make their own choices about the amount of physical activity they engage in on a daily basis. We have added this justification to the methods section of the paper (under 'participants' sub-heading): *"As we were interested in the factors influencing daily, habitual sitting time and physical activity, we specifically targeted people living at home later after stroke." (page 5)*
4. Lack of justification of selected outcome measures.	The choice of outcomes or factors we included in our exploratory

	analyses (ie walking ability, physical function, emotional function, stroke severity) was based on past research on factors relating to physical activity levels. In relation to the choice of tools to measure the outcomes of interest in the paper, the following statements in the original manuscript justify the choice of activity monitors: "…the activPAL directly measures posture. It has been shown to be highly accurate in classifying sitting and standing activities in people with stroke." (page 6) "This device (actigraph) has been shown to discriminate well between different movement speeds, ranging from slow walking (0.89 m/s) to moderate running (2.7 m/s)." (page 6) We based the choice of other outcome measures on those with the strongest psychometric properties (validity, reliability, accuracy) for the activities of interest, and these were fully referenced within the paper.
5.Describe any efforts to address potential sources of bias	The use of objective activity monitor data is a strength of this study, and limits bias in relation to self-reports of activity. The limitations of the study in relation to the available data and the external validity of the findings are outlined in the 'strengths and limitations' section of

	the paper. (page 12)
6. What happens if the participant is unable to complete the test?	Aside from the reported missing activity monitor data, all participants completed all other assessments, resulting in no other missing data.