Title: "Sedentary time and activity behaviours after stroke rehabilitation: changes in the first 3-months home"

Dawn B. Simpson[a, b] BSc. (Hons), Monique Breslin[a] PhD, Toby Cumming[c] PhD, Sam A. de Zoete[b] BAppSci (Physiotherapy), Seana L. Gall[a] PhD, Matthew Schmidt[d] PhD, Coralie English[e, f, g] PhD, and Michele L. Callisaya[a, h] PhD

[a]Menzies Institute of Medical Research, 17 Liverpool Street, University of Tasmania, Hobart, Tasmania. 7000 Australia

[b]Physiotherapy Department, Royal Hobart Hospital, Tasmanian Health Service – South, GPO Box 1061, Hobart, Tasmania. 7001 Australia

[c]Stroke Division, Florey Institute of Neurosciences and Mental Health, 245 Burgundy Street, Heidleberg, Victoria. 3084 Australia

[d]School of Health Sciences, 17 Liverpool Street, University of Tasmania, Hobart, Tasmania. 7000 Australia

[e]School of Health Sciences and Priority Research Centre for Stroke and Brain Injury, University of Newcastle, University Drive, Callaghan, Newcastle, NSW. 2308 Australia

[f]Centre for Research Excellence in Stroke Rehabilitation and Brain Recovery, University of Newcastle and Hunter Medical Research Institute, Lot 1 Kookaburra Circuit, New Lambton Heights, NSW. 2305 Australia

[g]School of Health Sciences and Alliance for Research in Exercise, Nutrition and Activity, University of South Australia, 101 Currie Street, Adelaide, South Australia. 5001 Australia

[h]Peninsula Clinical School, Central Clinical School, Monash University, Melbourne, Victoria, Australia

Corresponding author: Dr Michele Callisaya Michele.Callisaya@utas.edu.au

+61 418295933

Postal address: Menzies Institute for Medical research. 17 Liverpool Street, University of Tasmania, Hobart, Tasmania. 7000 Australia

Manuscript Details:

Manuscript word count: 3341

Abstract word count: 250

Number of figures: 1

Number of tables: 4

Number of references: 39

Sedentary time and activity behaviours after stroke rehabilitation: changes in the first 3-months home

Abstract

Background: Sedentary time is prevalent following stroke, limiting functional improvement and increasing cardiovascular risk. At discharge we examined: 1) change in sedentary time and activity over the following 3-months' and 2) physical, psychological or cognitive factors predicting any change. A secondary aim examined cross-sectional associations between factors and activity at 3-months.

Methods: People with a stroke (n=34) were recruited from 2 rehabilitation units. An activity monitor (ActivPAL3) was worn for 7-days during the first week home and 3-months later. Factors examined included physical, psychological and cognitive function. Linear mixed models (adjusted for waking hours) were used to examine changes in sedentary time, walking and step count over time. Interaction terms between time and each factor were added to the model to determine if they modified change over time. Linear regression was performed to determine factors cross-sectionally associated with 3-month activity.

Results: ActivPAL data was available at both time points for 28 (82%) participants (mean age 69 [SD 12] years). At 3-months participants spent 39 fewer minutes sedentary (95%CI -70,-8 p=0.01), 21 minutes more walking (95%CI 2,22 p=0.02) and completed 1112 additional steps/day (95%CI 268,1956 p=0.01), compared to the first week home. No factors predicted change in activity. At 3-months, greater depression (β 22 mins (95%CI 8,36) p=0.004) and slower gait speed (β -43 mins 95%CI -59,-27 p≤0.001) were associated with more sedentary time and less walking activity respectively.

Conclusions: Sedentary time reduced and walking activity increased between discharge home and 3-months later. Interventions targeting mood and physical function may warrant testing to reduce sedentary behaviour 3-months following discharge.

Key words – Sedentary time, Physical activity, Stroke, Rehabilitation, Depression, Gait speed

Introduction

People with stroke spend a large proportion of their day sedentary both in hospital and at home [1]. Prolonged sedentary time is associated with increased incidence of cardiovascular disease and mortality [2]. Recurrent stroke is common [3] and while guidelines recommend control of risk factors [4] this remains a challenge. Shifting behaviour along the continuum from sedentary to time upright and walking can target inactivity as a modifiable risk factor. Greater activity and regular breaks in sedentary time can positively influence blood pressure [5] and confer benefits for metabolic health [6]. Furthermore, activity is important for recovery of physical function [7].

In our previous study we identified that the transition from inpatient rehabilitation to home is a key time point: time spent sedentary is less and walking is greater in the first week home compared to the last week in hospital [1]. However increases in time upright and step count, largely appear to occur in the first three months after stroke [8], with little further change 6-12 months thereafter [9-11]. Additionally, in the years after stroke few people engage in physical activity [12]. Reducing sedentary time and establishing physical activity habits at a key time such as discharge home from hospital may help establish long term behaviours. However, little is understood regarding factors, particularly cognitive or psychological, that might influence change in sedentary and walking time in the first few months after discharge. Such knowledge may help health professionals predict which stroke survivors are more likely to positively change their activity after discharge to maximise their functional gains, and importantly predict people who may not change their activity behaviour without targeted support and interventions. However, no studies to our knowledge have examined factors that predict change in activity behaviours post discharge.

While understanding change in activity is important, so too is understanding factors that may be influencing activity at specific timepoints. Though not causal, this information may assist clinicians to identify what may be impacting activity at that time. Prior cross sectional analyses in the chronic phase after stroke have identified that slower walking speeds [13], greater stroke severity and poorer functional independence [14] are associated with greater sedentary time. Factors such as pre-stroke physical activity, greater walking endurance [15], lower levels of fatigue, greater daily step count [16], and higher levels of function and balance are associated with greater ambulatory activity [9]. Understanding factors that influence activity at timepoints earlier after discharge home may further assist clinicians design interventions to increase physical activity after stroke. One such timepoint is at 3-months following discharge when often outpatient rehabilitation programs are ending [17,18]. This time may also be an important transition point for therapists to target activity promotion after stroke.

Therefore, the aims of this study were to investigate whether sedentary and walking activity 1) changed between rehabilitation discharge and 3-months later and 2) factors (physical, psychological and cognitive) associated with change in 3-month activity. Our secondary aims were to 1) investigate whether sedentary time accumulated in prolonged bouts (>30 minutes and >60 minutes) changed between the first week at home and 3-months later and 2) examine factors associated cross-sectionally with activity at 3-months.

Methods

Participants

In this study, secondary analyses were conducted using data are from a longitudinal observational study was conducted between January 2015 and August 2016. Recruitment of participants (n=34) was from two public inpatient rehabilitation units (Acute Rehabilitation Unit and Geriatric Rehabilitation Unit) in southern Tasmania, Australia, with the methods and sample size calculation of the study reported previously [1]. In brief, eligibility criteria included admitted with diagnosis of stroke, ≥18 years of age, discharge home to the community, discharged from acute care to a rehabilitation facility for >7 days and able to walk prior to stroke. Exclusion criteria were discharge to a residential care facility and people not expected to survive >3 months post discharge. Written informed consent was obtained from each participant. Study approval was from the human research ethics committee approval numbers (H0014343) and (0000033796).

Measures

Physical activity measures

Activity was measured for seven-days using an activPAL3 triaxial accelerometer[a] during the first week at home after hospital discharge and 3-months later. The ActivPAL3 contains an inclinometer that determines posture and differentiates between sitting/lying and upright activity along with an accelerometer to determine step count and walking time. Outcomes included: *sedentary time*; *walking time* and *step count* per day. The monitors were waterproofed by research staff and attached to the participants non-paretic mid anterior thigh (dominant limb if no paresis present), with instructions to wear the device for seven full days. Participants further recorded in a diary if the monitor was removed, as well as the times they got up and went to bed to allow identification of sleep/wake time. Total sedentary time was defined as the total time spent in a sitting/lying posture during waking hours. Prolonged sedentary bouts were defined as sedentary durations > 30 and >60 minutes. Total walking time was defined as the total time spent walking during waking hours. The monitor is highly reliable (ICC 0.99) and valid in classifying sitting/lying postures in older populations including people with stroke [19]. A percentage difference between the mean of the activPAL3 and direct observation has been found to be less than 0.3%. In the stroke population, due to the known decrease in gait speed step count may be less accurate at slower (<0.47m/s) walking speeds [20].

Data processing

ActivPAL3 software (version 7.2.32) was used to download data. Wake and sleep times were obtained from participant diaries. If diary data was not available, research staff visually inspected activPAL3 event files to determine wake time. Waking hours were extracted using a custom-built program that linked the activPAL3 event file and participant diary data. Visual inspection of heat maps was conducted to check for possible errors of activity classification. If >95% of a day was spent in one posture without change, data was deemed invalid as it suggested removal of the monitor [21].

Other measures

Participant characteristics:

At baseline, during the final week of hospital rehabilitation, demographic data was collected from the medical record including: age, sex, date of stroke onset, side of lesion, type of stroke, ability to walk and presence of a carer at home. A neurologist assessed stroke severity using the National Institutes of Health Stroke Scale (NIHSS) on admission to hospital [22]. The NIHSS is scored against 11 criteria that assess vision, motor and sensory function, cognition, ataxia, inattention and speech and language function. From a total of 42 points, scores can be further categorised to indicate mild (range 0-7), moderate (range 8-15) and severe (range ≥16) stroke severity.

Physical, psychological and cognitive factors:

Physical, psychological and cognitive measures were obtained at baseline by senior inpatient rehabilitation clinicians (final week in hospital) and 3-months later at a clinic assessment by research staff. *Physical measures*: Gait speed was measured using the 10-meter walking test [23], walking endurance using the 6-minute walk [24], and lower limb strength with the five times sit-to-stand test [25]. These measures are valid and reliable in the stroke population [23-25]. The presence of pain (lower limb or spinal) at the time of assessment was categorised as present or not present. *Psychological measures*: Depression and anxiety were measured using the hospital anxiety and depression scale (HADS), where greater scores indicate greater depression and anxiety symptoms [26]. Fatigue was measured using the fatigue assessment scale (FAS) with greater scores indicating greater symptoms of fatigue [27]. Cognitive function was measured using the Montreal cognitive assessment (MoCA), which is scored from zero to 30, and is a valid and reliable tool in the post stroke population [28]. Greater scores indicate greater cognitive ability.

Data analysis

Descriptive statistics were used to describe participant characteristics.

Change in activity over time: Activity time (sitting, walking and step count) was reported for the two timepoints first week home and 3-months at home, and linear mixed models were used to estimate the mean difference adjusted for waking hours only.

Factors associated with change in activity over time: To identify factors that were associated with change in activity, interaction terms between time and each factor were added to the linear mixed models adjusted for waking time. Factors tested were age, sex, days post stroke, stroke severity, pain, living with carer, gait speed, lower limb strength, walking endurance, depression, anxiety, fatigue and cognition. For any significant predictors of change, confounding was addressed by adding further interaction terms between time and confounding variables (e.g. age, severity of stroke etc.).

Cross-sectional associations between factors and activity at 3 months: Linear regression analysis was used to examine associations between covariates and activity measure (adjusted for waking hours) at 3 months. A stepwise model (adjusted for waking hours) was built for each physical activity outcome. Entry criteria for the model was if an independent variable was significant in the univariable model. Independent variables were subsequently removed if not significant ($p<0.05$). Prior to entry to the model, independent variables were tested for multicollinearity. If variables were moderately to highly correlated ($r>0.6$). Significance was set at $p<0.05$ two-tailed for all variables. All analyses were conducted in Stata version 15.

This manuscript conforms to the STROBE Guidelines.

Results

Flow of participants through the study

Figure 1 shows the flow diagram of participants through the study. Of the 88 people with stroke that were admitted to rehabilitation during the recruitment period, 53 met eligibility criteria and 34 consented to participate, completing baseline (final week of rehabilitation) covariate measures and first week home activity monitoring. Activity monitor data was available for 32 (94%) participants at the first week home timepoint (one loss of monitor, one broken monitor).

At 3-month follow up, 31 (91%) participants completed measures and wore the activity monitor (mean age 69 [SD 13] years, n=16 (52%) male), with 3 people withdrawing from the study (too busy to attend the appointment x2, no reason supplied x1). Activity monitor data at 3-month follow up was deemed missing for a total of three recording days from one participant as it was identified that the monitor had been removed for these days, and the average of their 4-days data was included in the analysis. One participant was deemed to have removed the activity monitor within 24-hours of application and consequently their data was not included in the analyses. As such, twenty-eight (82%) participants had matched activity monitor data at both the first week home and 3-month timepoints. Participants had a mean age 69.1 [SD 12.7] years, 50% were male and had a mean NIHSS score of 7.4 [SD5.3] at stroke onset. Table 1 summarises the baseline and 3-month assessment characteristics for these 28 participants. A descriptive comparison of participants included at 3-months and those not followed up is shown in supplementary table 1. One participant was unable to answer the hospital anxiety and depression scale, fatigue assessment scale or the MoCA due to aphasia, and one participant was unable to attend the 3-month assessment due to a medical reason but still completed the activity monitor measurement.

Change in activity between first week home after discharge and 3-months

Participants spent a mean of 13.5 [SD 1.9] hours awake per day during the first week at home and a mean of 13.7 [SD 1.4] hours per day awake 3-months later. Table 2 presents the differences in overall activity between the first week at home and at 3-months, adjusted for waking hours. Significant differences were found for all activity outcomes. At 3-months, participants spent 39 fewer minutes sedentary, 21 minutes more walking and completed 1112 additional steps each day, compared to the first week following discharge. For secondary measures, total sedentary time accumulated in bouts of >30-minute durations significantly reduced by 44 minutes between the first week home and 3-months later. This represents a reduction from 70% to 62% of the total daily sedentary time accumulated in bouts >30mins. The total daily sedentary time accumulated in bouts of >60 minutes (reduction from 48% to 46% of total daily sedentary time) and the mean number of 30-minute and 60-minute sedentary bouts did not significantly change over time.

Factors associated with change in activity between first week home from hospital and 3-months

The linear mixed model revealed no statistically significant associations between physical, psychological or cognitive factors at baseline and change in sedentary, walking time or step count over the 3-month period (Table 3).

Cross-sectional associations between factors and activity at 3 months

Table 4 shows the results from the cross-sectional univariable models adjusted for waking hours. Greater scores for depression, fatigue, and slower walking speed were associated with greater total daily sedentary time ($p=0.009$, $p=0.007$ and $p=0.008$ respectively) and lower daily step count ($p=0.047$, $p=0.015$ and $p\leq0.001$ respectively). Greater fatigue ($p=0.014$), lower endurance ($p=0.001$), lower limb strength ($p=0.017$) and slower gait speed ($p\leq0.001$) were associated with less walking time. Greater lower limb strength ($p=0.034$) was associated with greater daily step count. No associations were found between age, sex, stroke severity, time post stroke, anxiety, cognition, pain or presence of a carer and activity outcomes (all $p<0.05$).

In the final multivariable models, covariates from both psychosocial (depression and fatigue $r=0.63$) and physical domains (gait speed and walking endurance $r=0.96$) were moderately to highly correlated with each other, and when both were added the multivariable models for each activity outcome, they both became non-significant. As such we built the final models by adding the variable from each domain that was most strongly associated with the outcome. In the final models that were further adjusted for age, only depression was independently associated with greater total sedentary time (β 22.3 mins (95% CI 7.9, 36.5) $p=0.004$) and only slower gait speed was independently associated with less total walking time (β 43.1 mins (95% CI 26.7, 59.5) $p \leq 0.001$) and step count (β 3780 (95% CI 2460, 5100) $p \leq 0.001$).

Discussion

The aim of this study was to investigate whether sedentary and walking activity changed during the first 3 months following discharge from inpatient stroke rehabilitation, and to examine whether factors might predict any change in activity over this time. We found that over 3 months daily sedentary time reduced and walking activity increased and that total sedentary time was accumulated in shorter (<30 minute) bouts at 3-months than in the first week at home. However, none of the baseline physical, psychological or cognitive factors explained the change in activity observed over the 3-months. Finally, at 3-months we found independent cross-sectional associations between greater depressive symptoms and higher daily sedentary time, and between slower gait speed and less walking time and step count.

We observed change in activity comparable with several longitudinal studies in the subacute period post stroke [9,10,29]. The magnitude of sedentary time reductions in our study (39 minutes over 3-months) was comparable to that found by other studies (30-minute reduction over 3-months [10]). This may reduce mortality risk [2] and improve cardiovascular health [30]. In contrast, one larger study (n=96) found no change in sedentary time between one, six and 12 months following stroke [14]. Differences in findings might be explained by differences in baseline stroke severity. In the larger study by Tieges et al [14], participant's average stroke severity was mild (NIHSS 2), whereas participants in our study had on average moderate stroke severity (NIHSS 7), suggesting that people with moderate stroke severity may have greater room for improvement in their activity levels early after stroke.

We further identified that the pattern of total daily sedentary time was accumulated in shorter bouts (<30 minutes) over the 3-months. This is important, as shorter sedentary bouts

<30 minutes are associated with less increased risk of all-cause mortality compared with people in the greatest sedentary risk profile (high total sedentary time and accumulation in long bouts) [2]. Converting this reduction in sedentary time to physical activity of any intensity confers even greater health benefits in older adults [31], and provides greater opportunities for ambulatory task practice. Achieving an additional 21 minutes of walking and an additional 1112 steps per day across the first 3-months at home may promote greater recovery of function. Though there are not yet clear recommendations for daily step count targets in populations with activity limitations, 3500-5000 steps per day has been suggested as a normative range [32]. Over the 3-month period the mean steps per day for participants in this study improved from below (2596 steps/day) to being within this range (4214 steps/day). Ongoing interventions could capitalise these gains further to improve function and build long term physical activity behaviours.

An ability for clinicians to predict who may and may not change their sedentary and activity behaviours once they leave hospital is potentially useful to engage and support people in strategies to increase activity and reduce further stroke risk. We did not identify any statistically significant factors assessed at hospital discharge that predicted change in activity over the following 3-months. This may be attributable to the sample size being insufficient to predict change in activity, since it is known that interaction terms require much larger samples than simple regression terms to be detectable [33]. A simulation using this data shows that assuming the effect sizes seen here, a sample size of 60 patients would provide enough power to find significant associations between change in steps/day and two factors: pain and the presence of a carer. An increase of sample size to 90 would add depression to that list. Though we collected a broad range of physical, psychological and cognitive measures, once at home in the community there may be other drivers of sedentary behaviour and activity. Early therapy and support, social and environmental factors, personal motivation and selfefficacy for activity may influence behaviour change for people with stroke more than physical, psychological and cognitive factors [34-36]. Factors influencing sedentary and physical activity behaviours are likely to be complex and multifactorial. This poses a challenge for clinicians and stroke survivors at hospital discharge when aiming to implement strategies to reduce sedentary time and maximise activity in the longer term.

We did identify factors that were cross-sectionally associated with sedentary time and walking activity 3-months after hospital discharge. Higher depression was independently associated with sedentary time, suggesting that mood is important to monitor and treat as it can vary after stroke [37]. With known bidirectional associations between mood and activity [38], we cannot discount that other factors such as level of disability could be influencing sedentary time. However, at 3-months participants demonstrated a mean gait speed of 1.1m/s, suggesting that for some it is less likely that disability was impacting on sedentary time. An ability to walk well provides opportunities to resume pre-stroke life roles, leisure activities and to access the community [39]. Faster walking speed at 3-months was associated with greater daily walking time and step count. Sedentary time can be high even with better functional ability [14,40]. Despite a reduction, participants still spent 9.7 hours of their waking day sedentary. There remains great potential within a 24-hour period to increase walking that could enhance both functional recovery [7] and cardiovascular health [30]. This may require behaviour change interventions for community ambulant people, and for those with limited ambulatory ability, interventions targeting gait speed during outpatient therapy can progress people into a higher ambulation category (household, limited community, full community) that improves function and quality of life [41].

Strengths and limitations

This study has several strengths. Sedentary time and walking activity were measured using a validated objective device and there was careful identification and analysis of waking hours. To allow a unified approach for fixed effects and repeated measures, the analysis was conducted using linear mixed models. The sample included a range of presentation of stroke severity and walking ability ensuring that the broader stroke population are represented. Finally, the interaction between a broad range of physical, psychological and cognitive factors and time were examined, however psychosocial factors such as ongoing therapy interventions were not explored. There are some limitations in this study. As noted previously the analysis was underpowered to detect some associations, specifically factors associated with change over the 3-month follow up period. As our analyses were exploratory, a sample size calculation was not conducted for the longitudinal analysis and this is a study limitation. A small number of people were not included in the analyses either due to withdrawal from the study or loss of activity monitor data. Information on ongoing outpatient therapy was not included in our dataset. Consequently, some participants may have been more physically active as a result of engagement in therapy sessions which could have impacted our results by overestimating the improvements in activity measures observed. Participants not included in the change in activity analysis were slightly younger, more likely to be depressed, anxious or fatigued and less likely to be an independent walker at hospital discharge. Finally, while highly accurate to detect sedentary time, for people with very slow walking speeds the activPAL3 monitor can underestimate step count which may have impacted data for 4 participants in this study [42].

Conclusion

In conclusion we observed reduced sedentary time, and greater walking activity in people with stroke at the 3-month time-period following inpatient rehabilitation discharge. However, we were unable to identify factors that explained this change in activity behaviour.

Depression was associated with sedentary time and gait speed with walking time and step count at 3-months. Rehabilitation should be maximised following discharge to optimise recovery and facilitate long-term physical activity behaviours.

Acknowledgements

We would like to acknowledge the support of Frank Nicklason and the Department of Geriatrics Tasmanian Health Service South, Helen Castley and the Department of Neurology Tasmanian Health Service South, and the Department of Physiotherapy Tasmanian Health Service South.

Funding

This study was funded by a project research grant from the Department of Geriatrics, Royal Hobart Hospital, Tasmanian Health Service-South. DS is supported by a Commonwealth Department of Health nursing and allied health postgraduate scholarship. MC is supported by an NHMRC Dementia Research Fellowship (#1135761). CE is supported by a Heart Foundation of Australia Future Leaders Fellowship (#101177). SG is supported by a Heart Foundation of Australia Future Leaders Fellowship (#100446).

Conflicts of interest: None

References

1. Simpson DB, Breslin M, Cumming T, et al. Go Home, Sit Less: The Impact of Home Versus Hospital Rehabilitation Environment on Activity Levels of Stroke Survivors. *Archives of physical medicine and rehabilitation.* 2018;99(11):2216-2221. e2211.
2. Diaz KM, Howard VJ, Hutto B, et al. Patterns of sedentary behavior and mortality in US middle-aged and older adults: a national cohort study. *Annals of internal medicine.* 2017;167(7):465-475.
3. Edwards JD, Kapral MK, Fang J, Swartz RH. Long-term morbidity and mortality in patients without early complications after stroke or transient ischemic attack. *CMAJ.* 2017;189(29):E954-E961.
4. Foundation S. Clinical Guidelines for Stroke Management 2017. *Melbourne, Australia.* 2017.
5. English C, Janssen H, Crowfoot G, et al. Frequent, short bouts of light-intensity exercises while standing decreases systolic blood pressure: Breaking Up Sitting Time after Stroke (BUST-Stroke) trial. *International Journal of Stroke.* 2018;13(9):932-940.
6. Duvivier BM, Bolijn JE, Koster A, Schalkwijk CG, Savelberg HH, Schaper NC. Reducing sitting time versus adding exercise: differential effects on biomarkers of endothelial dysfunction and metabolic risk. *Scientific reports.* 2018;8(1):8657.
7. French B, Thomas LH, Coupe J, et al. Repetitive task training for improving functional ability after stroke. *Cochrane database of systematic reviews.* 2016(11).
8. Fini NA, Holland AE, Keating J, Simek J, Bernhardt J. How physically active are people following stroke? Systematic review and quantitative synthesis. *Physical therapy.* 2017;97(7):707-717.
9. Askim T, Bernhardt J, Churilov L, Fredriksen KR, Indredavik B. Changes in physical activity and related functional and disability levels in the first six months after stroke: a longitudinal follow-up study. *Journal of Rehabilitation Medicine.* 2013;45(5):423-428.
10. Moore SA, Hallsworth K, Plötz T, Ford GA, Rochester L, Trenell MI. Physical activity, sedentary behaviour and metabolic control following stroke: a cross-sectional and longitudinal study. *PloS one.* 2013;8(1):e55263.
11. Murray CJ, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet (London, England).* 2012;380(9859):2197-2223.
12. Simpson D, Callisaya ML, English C, Thrift AG, Gall SL. Self-reported exercise prevalence and determinants in the long term after stroke: The North East Melbourne Stroke Incidence Study. *Journal of Stroke and Cerebrovascular Diseases.* 2017;26(12):2855-2863.
13. Hendrickx W, Riveros C, Askim T, et al. Identifying factors associated with sedentary time after stroke. Secondary analysis of pooled data from nine primary studies. *Topics in stroke rehabilitation.* 2019:1-8.
14. Tieges Z, Mead G, Allerhand M, et al. Sedentary Behavior in the First Year After Stroke: A Longitudinal Cohort Study With Objective Measures. *Archives of Physical Medicine and Rehabilitation.* 2015;96(1):15-23.
15. Mahendran N, Kuys SS, Brauer SG. Which impairments, activity limitations and personal factors at hospital discharge predict walking activity across the first 6 months poststroke? *Disability and rehabilitation.* 2019:1-7.
16. Duncan F, Lewis SJ, Greig CA, et al. Exploratory longitudinal cohort study of associations of fatigue after stroke. *Stroke.* 2015;46(4):1052-1058.
17. Conroy BE, DeJong G, Horn SD. Hospital-based stroke rehabilitation in the United States. *Topics in stroke rehabilitation.* 2009;16(1):34-43.
18. Rice D, Janzen S, McIntyre A, Vermeer J, Britt E, Teasell R. Comprehensive outpatient rehabilitation program: hospital-based stroke outpatient rehabilitation. *Journal of Stroke and Cerebrovascular Diseases.* 2016;25(5):1158-1164.

19. Grant PM, Ryan CG, Tigbe WW, Granat MH. The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. *British Journal of Sports Medicine.* 2006;40(12):992-997.
20. Taraldsen K, Askim T, Sletvold O, et al. Evaluation of a body-worn sensor system to measure physical activity in older people with impaired function. *Physical therapy.* 2011;91(2):277-285.
21. Winkler EA, Bodicoat DH, Healy GN, et al. Identifying adults' valid waking wear time by automated estimation in activPAL data collected with a 24 h wear protocol. *Physiological measurement.* 2016;37(10):1653.
22. Goldstein LB, Samsa GP. Reliability of the National Institutes of Health Stroke Scale extension to non-neurologists in the context of a clinical trial. *Stroke.* 1997;28(2):307-310.
23. Collen FM, Wade DT, Bradshaw CM. Mobility after stroke: reliability of measures of impairment and disability. *International disability studies.* 1990;12(1):6-9.
24. Fulk GD, Echternach JL, Nof L, O'Sullivan S. Clinometric properties of the six-minute walk test in individuals undergoing rehabilitation poststroke. *Physiotherapy theory and practice.* 2008;24(3):195-204.
25. Mong Y, Teo TW, Ng SS. 5-repetition sit-to-stand test in subjects with chronic stroke: reliability and validity. *Archives of physical medicine and rehabilitation.* 2010;91(3):407-413.
26. Aben I, Verhey F, Lousberg R, Lodder J, Honig A. Validity of the Beck Depression Inventory, Hospital Anxiety and Depression Scale, SCL-90, and Hamilton Depression Rating Scale as screening instruments for depression in stroke patients. *Psychosomatics.* 2002;43(5):386-393.
27. Cumming TB, Mead G. Classifying post-stroke fatigue: Optimal cut-off on the Fatigue Assessment Scale. *Journal of psychosomatic research.* 2017;103:147-149.
28. Cumming T, Churilov L, Lindén T, Bernhardt J. Montreal Cognitive Assessment and Mini–Mental State Examination are both valid cognitive tools in stroke. *Acta Neurologica Scandinavica.* 2013;128(2):122-129.
29. Sánchez MC, Bussmann J, Janssen W, et al. Accelerometric assessment of different dimensions of natural walking during the first year after stroke: Recovery of amount, distribution, quality and speed of walking. *Journal of rehabilitation medicine.* 2015;47(8):714-721.
30. van der Berg JD, van der Velde J, de Waard E, et al. Replacement Effects of Sedentary Time on Metabolic Outcomes-The Maastricht Study. *Medicine and science in sports and exercise.* 2017.
31. Diaz KM, Duran AT, Colabianchi N, Judd SE, Howard VJ, Hooker SP. Potential Effects on Mortality of Replacing Sedentary Time With Short Sedentary Bouts or Physical Activity: A National Cohort Study. *American journal of epidemiology.* 2019;188(3):537-544.
32. Tudor-Locke C, Craig CL, Aoyagi Y, et al. How many steps/day are enough? For older adults and special populations. *International Journal of Behavioral Nutrition and Physical Activity.* 2011;8(1):80.
33. Leon AC, Heo M. Sample sizes required to detect interactions between two binary fixed-effects in a mixed-effects linear regression model. *Computational statistics & data analysis.* 2009;53(3):603-608.
34. Ezeugwu VE, Garga N, Manns PJ. Reducing sedentary behaviour after stroke: perspectives of ambulatory individuals with stroke. *Disability and rehabilitation.* 2017;39(25):2551-2558.
35. Morris JH, Oliver T, Kroll T, Joice S, Williams B. From physical and functional to continuity with pre-stroke self and participation in valued activities: a qualitative exploration of stroke survivors', carers' and physiotherapists' perceptions of physical activity after stroke. *Disabil Rehabil.* 2015;37(1):64-77.

36. Nicholson SL, Donaghy M, Johnston M, et al. A qualitative theory guided analysis of stroke survivors' perceived barriers and facilitators to physical activity. *Disabil Rehabil.* 2014;36(22):1857-1868.
37. Townend B, Whyte S, Desborough T, et al. Longitudinal prevalence and determinants of early mood disorder post-stroke. *Journal of Clinical Neuroscience.* 2007;14(5):429-434.
38. Pereira SMP, Geoffroy M-C, Power C. Depressive symptoms and physical activity during 3 decades in adult life: bidirectional associations in a prospective cohort study. *JAMA psychiatry.* 2014;71(12):1373-1380.
39. Schmid A, Duncan PW, Studenski S, et al. Improvements in speed-based gait classifications are meaningful. *Stroke.* 2007;38(7):2096-2100.
40. English C, Healy GN, Coates A, Lewis LK, Olds T, Bernhardt J. Sitting time and physical activity after stroke: physical ability is only part of the story. *Topics in stroke rehabilitation.* 2015:1-10.
41. Grau-Pellicer M, Chamarro-Lusar A, Medina-Casanovas J, Serdà Ferrer B-C. Walking speed as a predictor of community mobility and quality of life after stroke. *Topics in stroke rehabilitation.* 2019;26(5):349-358.
42. Reid N, Eakin E, Henwood T, et al. Objectively measured activity patterns among adults in residential aged care. *International journal of environmental research and public health.* 2013;10(12):6783-6798.

Suppliers

[a] activPAL3: PALtechnologies. 50, Richmond Street, Glasgow, G11XP. Scotland, United Kingdom

Figure legend

Figure 1. Participant flow during the study

Table 1. Baseline and 3-month characteristics of participants (n=28)

Characteristics:	Baseline		3-months	
	n	(%)	n	(%)
Age (*years*) mean (SD)	69.1	(12.7)		
Male	14	(50.0)		
Days since stroke mean (SD)	43.3	(26.7)		
NIHSS score at stroke onset mean (SD)	7.4	(5.3)		
Independent walking	22	(78.6)	24	(85.7)
Use of gait aid	17	(60.7)	13	(42.8)
Depression score* mean (SD)	3.1	(2.4)	6.0	(3.9)
Anxiety score* mean (SD)	4.7	(4.1)	6.2	(4.4)
Fatigue score* mean (SD)	21.1	(7.0)	23.3	(8.3)
6MW (*m*) mean (SD)	282	(164)	345	(181)
5xSTS (*sec*) mean (SD)	15.2	(6.1)	17.9	(14.8)
Gait speed (*m/s*) mean (SD)	1.00	(0.58)	1.09	(0.62)
MoCA score[#] mean (SD)	22.4	(5.4)	22.6	(5.5)
Pain present	9	(32.1)	8	(28.6)
Living with carer	19	(67.9)	19	(67.9)

NIHSS: National Institute Health Stroke Severity Score; 6MW: Six-minute walk test; 5xSTS: 5 times sit to stand test; MoCA: Montreal Cognitive Assessment

*n=26; [#]n=26

Table 2. Mean activity time at 1-week home, 3-months and adjusted mean differences in activity time post hospital discharge (n=28)

Activity type (Total mins/day)	Week 1 home mean	(SD)	3-months home mean	(SD)	Adjusted mean difference (mins)*	95% CI		p-value
Sedentary time	625	(160)	585	(146)	-39	-70	-8	**0.01**
Walking time	39	(30)	57	(43)	21	2	22	**0.02**
Steps/day	2596	(2266)	4214	(3639)	1112	268	1956	**0.01**
Total sedentary time accumulated in bouts >30 mins	438	(192)	390	(174)	-44	-83	-5	**0.03**
Total sedentary time accumulated in bouts >60 mins	302	(204)	270	(168)	-29	-69	7	0.12
Number of sedentary bouts > 30 mins	5.9	(1.6)	5.5	(2.0)	-0.43	-1.1	0.3	0.22
Number of sedentary bouts > 60 mins	2.7	(1.2)	2.6	(1.4)	-0.04	-0.45	0.36	0.83

*A linear mixed model was used with activity time as outcome and timepoint (week 1 or 3-months) as exposure. The model was adjusted for waking hours. Bold indicates p<0.05

Table 3: Predictors of change in each activity outcome between first week at home and 3-months later (n=28)*

	Activity time (minutes)								
Predictor	Sedentary time			Walking time			Step count		
	β	(95% CI)	p-value	β	(95% CI)	p-value	β	(95% CI)	p-value
Age (*y*)	0.8	(-1.8, 3.4)	0.56	-0.2	(-1.0, 0.6)	0.67	-27	(-98, 43)	0.45
Male	-5.1	(-65.6, 55.5)	0.86	1.3	(-18.0, 20.7)	0.89	36	(-1629, 1701)	0.96
NIHSS	2.6	(-3.4, 8.6)	0.39	0.8	(-1.1, 2.7)	0.39	72	(-91, 234)	0.38
Time post stroke (*d*)	0.8	(-0.4, 1.9)	0.19	0.1	(-0.3, 0.4)	0.76	7	(-25, 39)	0.68
Depression	10.1	(-2.9, 23.1)	0.13	-2.2	(-6.5, 2.0)	0.30	-181	(-546, 184)	0.33
Anxiety	5.0	(-2.8, 12.9)	0.21	-0.3	(-2.9, 2.3)	0.83	-33	(-254, 189)	0.77
Fatigue	2.1	(-1.8, 5.9)	0.29	0.3	(-1.7, 1.1)	0.64	-32	(-155, 92)	0.61
MoCA	-2.2	(-7.5, 3.2)	0.42	-0.5	(-2.5, 1.4)	0.59	-41	(-210, 127)	0.63
Mean gait speed (*m/s*)	-43.9	(-96.7, 8.9)	0.10	2.6	(-14.8, 19.9)	0.77	30	(-1459, 1519)	0.97
6MWT (10 *m*)	-1.0	(-3.0, 3.0)	0.49	-0. 1	(-0. 7, 0. 5)	0.76	-10	(-70, 40)	0.64

Pain	14.8	(-49.6, 79.2)	0.65	-14.0	(-34.1, 5.9)	0.16	-1161	(-2887, 564)	0.18
Carer	-30.4	(-93.8, 32.9)	0.34	16.7	(-2.9, 36.4)	0.09	1644	(-23, 3312)	0.05

*Each factor is in a separate model; β = for interaction; Bold = $p<0.05$

Abbreviations: NIHSS: National Institute Health Stroke Severity score; MoCA: Montreal cognitive assessment, 6MWT: 6-minute walk test, 5xSTS: 5-time sit-to-stand test

Table 4. Cross-sectional univariable associations between factors and activity outcomes adjusted for waking hours 3-months after hospital discharge (n=31)

Factors	Sedentary time*		Walking time*		Step count	
	β	(95% CI)	β	(95% CI)	β	(95% CI)
Age (*y*)	0.8	(-3.6, 5.4)	-0.8	(-0.2, 0.6)	-56	(-152, 40)
Male	10.4	(-101.4, 121.8)	16.4	(-13.8, 46.8)	-1575	(-900, 4045)
NIHSS	5.3	(-5.4, 16.2)	0.2	(-3, 3)	21	(-227, 269)
Time post stroke (*d*)	1. 6	(-0.6, 3.6)	-0.4	(-1.2, 0.0)	-31	(-68, 6)
Depression	**18.8**	**(4.8, 32.4)**	-3.7	(-7.8, 0.6)	**-340**	**(-674, -5)**
Anxiety	10.2	(-2.4, 22.8)	-2.8	(-7.2, 0.6)	-285	(-572, 2)
Fatigue	**8.9**	**(2.4, 15.0)**	**-2.3**	**(-4.2, -0.6)**	**-189**	**(-338, -40)**
MoCA	-2.9	(-15.0, 9.6)	1.5	(-1.8, 4.8)	118	(-184, 420)
Mean gait speed (*m/s*)	**-105.7**	**(-181.8, -29.4)**	**43.3**	**(26.4, 60.0)**	**3792**	**(2452, 5132)**
6MWT (10 *m*)	-3.0	(-6.0, 0.1)	**1.0**	**(1.0, 2.0)**	110	(50, 170)
5xSTS test (*s*)	0.2	(-1.8, 5.4)	**-1.3**	**(-2.4, -0.0)**	**-94**	**(-180, -8)**
Pain	-90.2	(-216.6, 36.0)	18.5	(-17.4, 54.6)	1237	(-1760, 4234)

Carer at home	16.1	(-105, 137.4)	5.2	(-28.8, 39.0)	594	(-2168, 3357)

*Time in minutes. Bold indicates $p<0.05$

Abbreviations: NIHSS: National Institute Health Stroke Severity score; MoCA: Montreal cognitive assessment, 6MWT: 6-minute walk test, 5xSTS: 5-time sit-to-stand test