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Research Article

Acute Hospital Admission for Stroke Is Characterised by Inactivity

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Background. Measuring physical activity behaviours of stroke survivors in the inpatient setting is challenging. Authors of observational studies of early poststroke report that stroke survivors are "inactive and alone". Using activity monitoring devices may help refine clinical practice and inform therapeutic activity targets. *Aim*. To measure the physical activity behaviour of stroke survivors during acute inpatient hospitalisation. We hypothesized that greater levels of inactivity would be positively associated with stroke severity and age. *Method*. Using a cross-sectional study design, consecutive stroke patients admitted to an acute stroke unit (Geelong, Australia) and recruited within 48 hours of admission had their physical activity recorded using an ActivPAL™ accelerometer device over a minimum of 3 days. Activity was categorised as time spent inactive (lying or sitting), standing, or stepping. The number of steps per day was recorded. Demographic and ActivPal™ data are described. *Results*. Seventy-eight stroke survivors were recruited of whom 54 had complete data for 3 days, all starting within 2 days poststroke. Of the 54 participants, 32 had a mild stroke, 17 moderate, and five severe stroke. Nine were able to walk independently at admission. The median age was 82.5 years (interquartile range (IQR) 74-86), 26 were female. On average, during their inpatient stay, participants spent a median of 98% of their admission inactive. A median of 18 minutes per day was spent standing and less than a minute per day was spent walking amounting to a median of 169 steps taken per day. *Conclusion*. The ActivePal™ device was feasible to use in an acute stroke setting. We observed high levels of inactivity in the first days post-stroke, highlighting the ongoing challenge of promoting activity in the acute stroke period. To our knowledge, this is the largest study to provide objective data on time spent upright, walking, and sedentary using accelerometer data in an acute stroke setting.

1. Background

Inactivity is associated with a greater risk of cardiovascular disease [1] and poor functional outcomes at three-month poststroke [2]. Physical activity is a requirement to improve and maintain physical fitness and can also mediate the detrimental effects of prolonged inactivity [3]. Fini et al. conducted a large systematic review on physical activity after stroke, which included 103 studies that measured physical activity using different methods (i.e., behavioural mapping, accelerometers) and at different times poststroke [4]. The results of the review showed stroke survivors spent 78% of time sedentary regardless of time poststroke [4]. Therefore, survivors of stroke stand to gain important beneficial effects of physical activity on cardiovascular disease risk factors and functional capabilities [5].

In clinical practice guidelines, it is recommended that out of bed activity within a few days of stroke should be encouraged unless otherwise contraindicated [5, 6]. However, the results of A Very Early Rehabilitation Trial (AVERT) demonstrated that intensive, very early mobilisation started within 24 hours of stroke and continued across the acute hospital phase could be harmful [7]. What remains unclear is what amount of physical activity should be recommended after stroke. Additionally, very few investigators have measured physical activity as part of their studies conducted in the acute phase after stroke [4]. In the majority of studies, physical activity is measured within the first weeks after stroke using observational behavioural mapping [8]. For example, Prakash et al. investigated the amount and patterns of physical activity of stroke survivors ($n = 47$) admitted to a medical ward in India [9], and Astrand et al. investigated physical activity of stroke survivors ($n = 86$) admitted to an acute stroke ward in Sweden [10]. In both studies, intermittent observational mapping was used where participants were observed at 10-minute intervals during the most active part of the day only (e.g., 8 : 30 am to 6 : 00 pm) [9, 10]. This method has disadvantages: it is labour and time intensive, and it is often limited to weekdays and during usual work hours. Additionally, it is problematic to capture the intensity and frequency of the activity, and behavioural mapping only provides a snapshot of activity for an individual patient during the observation period, which is usually limited to one or two days.

An alternative to behavioural mapping is the use of monitoring devices, which are now commonly used to objectively measure physical activity after stroke [8]. These devices are advantageous in their capacity to measure and store data continuously over time, are minimally intrusive, and once attached, can often remain in situ for days. Several investigators have used accelerometer-based devices in the acute phase (≤7 days) after stroke to quantify physical activity. In the study by Sanchez et al. [11], 23 participants who were able to independently perform sit-to-stand were included. The researchers recorded a single day (10 : 00 am to 6 : 00 pm) of the participants' activity, they failed to take advantage of the monitoring device to measure continuously over several days, and thereby providing more robust and representative data. In the study ($n = 31$) by Moore et al., activity of stroke survivors was recorded continuously over 7 days [12]. In a larger study ($n = 100$) by Strommen et al. of people with stroke or TIA, physical activity was measured using five accelerometer-based devices, one placed on each limb and one at the hip for a median of 47.0 hours (range, 2.0–167.0 hours) [13]. The output of this device is activity counts calculated by proprietary algorithms. This output is not easy to interpret, and it is not possible to transform the data into a clinically meaningful outcome such as step counts or time spent active. Overall, the type of devices used, populations, and protocols vary across studies involving participants during the acute stroke phase. This limits our ability to compare outcomes between studies and hampers understanding of physical activity behaviour early after stroke.

Objectively characterising activity levels, by continuously measuring activity over several days, of patients with different levels of stroke severity in the acute inpatient setting would be informative to further develop physical activity recommendations in the early phase of stroke recovery. A device previously used in stroke research to measure physical activity is ActivPAL™ (PAL Technologies Ltd©, Glasgow, UK). ActivPAL™ is able to provide data on step count, as well as time spent inactive (resting in bed, sitting), standing, and moving (transferring, walking, and running). It has been shown to be a valid and reliable tool to measure step count and time spent inactive, standing, and moving in healthy people [14, 15] and in people with stroke [16].

The aims of this study were to describe the physical activity patterns of patients with acute stroke during hospitalisation and to examine the relationship between the physical activity behaviour of patients with stroke and their stroke severity. We hypothesised that acute stroke patients would be mostly inactive (i.e., lying and sitting) early after stroke. We also hypothesized that greater levels of time spent inactive would be positively associated with (1) stroke severity and (2) age at the time of stroke.

2. Method

This is a cross-sectional, observational study of patients with stroke admitted to an acute stroke unit located in Geelong, Australia.

2.1. Participants. Adults over the age of 18 with a confirmed diagnosis of stroke who were admitted directly to the stroke unit at the Geelong Hospital, Barwon Health, from the hospital emergency department were eligible for inclusion. Participants were eligible regardless of stroke severity and were consecutively recruited into the study, unless all available ActivPAL™ devices were in use. Additionally, patients were eligible to participate if they were within 48 hours of admission to the stroke unit.

Patients were excluded if they were diagnosed with subarachnoid haemorrhage and transient ischaemic attack (TIA), as the recommended management strategies for these patients are different to those for the other types of stroke (ischaemic and nonsubarachnoid hemorrhagic stroke). Patients were excluded if they had their stroke while in hospital for another admission reason as this may have affected their inpatient management. If patients were allergic to adhesives or latex and, therefore unable to wear the ActivPAL™ device, they were also excluded.

2.2. Procedure. The admission list for the stroke unit at Geelong Hospital, Barwon Health, was screened daily between June 2012 and December 2012 to identify eligible participants. The participants themselves or a person responsible provided informed written consent. Ethical approval for this study was granted by Barwon Health Human Research Ethics Committee (Approval Number HREC/11/VICBH/38) and La Trobe University Health Science Faculty Human Research Ethics Committee (Approval Number UHEC No. 11-065).

Physical activity was monitored using ActivPAL™, a small device worn on the upper thigh that uses static and dynamic accelerometry data to distinguish sitting/lying, standing, and stepping. Following enrolment, each participant was given an ActivPAL™ device to wear. Before attaching the device to the anterior aspect of the upper $^{1}/_{3}$ of the thigh on the paretic side, the device was reset and reloaded and wrapped in a protective Tegaderm™ (3M, St Paul, USA) dressing to seal the device and provide a moisture barrier. Another Tegaderm™ was used to attach the ActivPAL™ to the paretic leg. A gauze dressing was used as a barrier between the Tegaderm™-wrapped ActivPAL™ and the participant's skin. Once in place, the ActivPAL™ remained in situ until the participant was discharged from the stroke unit or at 14 days after admission (whichever was earliest). The physical activity data were categorised as (1) percentage of time spent sitting or lying, (2) percentage of time spent standing, (3) percentage of time spent stepping, and (4) step counts.

Participant characteristics were collected from medical records and included demographic data and stroke characteristics.

Premorbid degree of disability was assessed using the 7-point modified Rankin Scale (mRS) [17]. Premorbid mRS ranges from 0 = no symptoms at all to 5 = severe disability (i.e., requires constant nursing care and attention, bedridden, incontinent). A score of 6 indicating death was not used.

Prestroke walking ability was assessed by the attending physiotherapist in consultation with the participant.

Stroke type was classified according to the Oxfordshire Community Stroke Program (OCSP) classification [18]. The OCSP is used to classify stroke into five types: total anterior circulation infarct (TACI), lacunar infarct (LACI), partial anterior circulation infarct (PACI), posterior circulation infarct (POCI), and haemorrhage.

Stroke severity was measured by a certified physiotherapist using the National Institutes of Health Stroke Scale (NIHSS) [19]. The NIHSS is an 11 item-scale with scores ranging from 0 to 44. A higher score indicates greater stroke severity. Stroke severity was categorised into mild (NIHSS 0-7), moderate (NIHSS 8-16), and severe (NIHSS > 16) [20].

Poststroke mobility was measured by the treating physiotherapist using the Mobility Scale for Acute Stroke (MSAS) at baseline [21, 22]. The participants were grouped into independent or dependent ambulation categories based on an MSAS gait score of ≥6, respectively.

Adverse events were monitored throughout the study and included any event related to wearing the device (e.g., skin rash).

2.2.1. Data Processing and Analysis. No official sample size calculation was performed for this study. Data were downloaded from the ActivPal™ devices using ActivPal™ software. Proprietary algorithms were used to classify the accelerometer data time spent walking, stepping, and lying down/sitting and number of steps. Physical activity outcomes were only summarised for participants who wore the device for at least three consecutive days, as recommended by Tinlin et al. [23] Inactivity is defined by the time spent lying/sitting. Logic checks were performed to ensure data accuracy. A random 10% sample of manually entered data was reentered by a second researcher and assessed for agreement using the intraclass correlation coefficient (ICC) with 95% confidence intervals. Descriptive statistics were used to summarise demographic and ActivPal™ data.

We expected that patients with acute stroke would be inactive in the early part of their inpatient hospital stay. Inactivity was defined as more than 16 hrs per day (24 hrs) spent sitting or lying down. We chose this cut-off under the assumption that on average, 8 hrs spent sleeping and adding another 8 hours of sitting and lying (i.e., 16 hours in total per 24 hours) is equal to 50% of the time awake spent inactive. Descriptive statistics were used to report the daily percentage of time spent in each category, i.e., time spent inactive (time spent lying/sitting) and time spent active (time spent upright and stepping) averaged over the three days (72 hours) of monitoring. We also calculated the mean number of daily steps taken by using the average over three days of monitoring during the inpatient stay. We used Spearman correlation coefficients to test the hypothesis that greater levels of inactivity were positively associated with age and stroke severity.

STATA 13 (Statistical Software, College Station, TX: StataCorp LP) was used for all analyses. Level of significance was set at $p < .05$.

3. Results

One-hundred and thirty-one patients with acute stroke were screened for inclusion, of whom 100 were eligible for inclusion. Of these, 82 were enrolled in the study (see Figure 1). Two participants commenced monitoring but did not tolerate wearing the device and two participants wore the device, but no data were collected due to device failure. Of the 78 participants from whom data were collected, 54 had complete data for three days (see Figure 1).

Participant demographic and stroke data are reported in Table 1. The median length of stay in the stroke unit was five days (interquartile range (IQR): 2 to 8 days), and the participants wore the ActivPAL™ for a median duration of four days (IQR: 2 to 6 days). The monitoring started between 0 and 3 days since hospitalisation, with a median of one day after admission. Participants experienced a number of secondary complications during their inpatient hospitalisation, including pneumonia (3 participants), a fall (4 participants), ulcers (2 participants), recurrent stroke (1 participant), stroke progression (5 participants), urinary tract infection (5 participants), myocardial infarction (3 participants), and fever (4 participants). Twenty-four participants experienced other complications (36 in total), including hypertension, pain, and depression.

Twenty-four participants were monitored less than three days because of discharge from the stroke unit. Fourteen of these 24 participants were able to walk independently on admission and all had a mild stroke. This is compared with the 54 participants who were monitored three days or more of whom only 9 were able to walk independently and 32 had a mild stroke (see Table 1).

3.1. Physical Activity. Physical activity data were analysed for the 54 participants who were monitored for at least three consecutive days. These participants spent most of their day (24 hrs) inactive (median 98%, IQR 97%-99%) with only 1% (18 minutes) of the day spent standing (IQR 1% to 3%) and less than 1% walking (less than a minute) or stepping (IQR 0% to 1%). The median number of steps taken per day was 169 (IQR 12 to 522 steps per day).

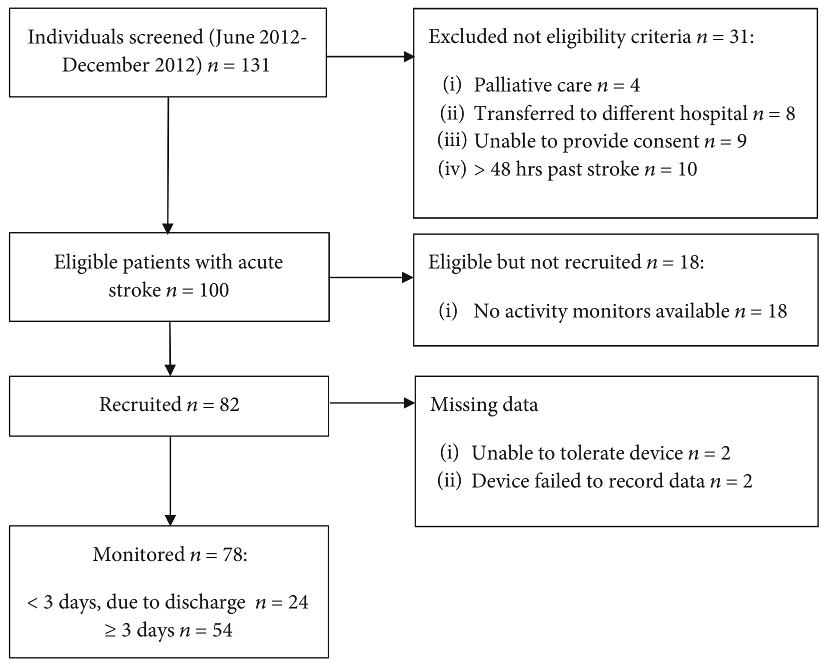

Figure 1: Flow diagram of screened and included acute stroke patients.

3.2. Impact of Age and Stroke Severity on Physical Activity. To answer the hypothesis that greater levels of inactive behaviours would be positively associated with greater disease severity, we calculated Spearman correlation coefficients (r_s) between the daily minutes spent inactive and NIHSS and the daily minutes spent inactive and age. We found a weak, nonsignificant correlation between time spent inactive and age ($r_s = 0.25$, $p = 0.07$) and a moderate positive and significant correlation between time spent inactive and stroke severity ($r_s = 0.45$, $p < 0.001$) (see Figure 2).

4. Discussion

This study is one of the two large studies to date to objectively monitor physical activity of patients admitted to an acute stroke ward. To our knowledge, it is the only study that provides data on time spent upright, walking, and sedentary time in patients during the first few days after a stroke. The ActivePal™ device was feasible to use in this setting, with low rates of device failure or adverse events related to wear. None of the patients spent less than 16 hrs inactive, with a median of 23 hrs per day spent lying and sitting. On average, we commenced recording of patient activity within 24 hrs of admission to a stroke unit. Despite this early start, many patients were discharged quickly from the acute stroke unit, and we were unable to gather three complete days of physical activity data for the full sample.

The study of Strommen et al. is the only other large physical activity study in which 100 acute patients with stroke or TIA were included [13]. The patients wore five Actical accelerometers, one placed at each limb and one at the hip for ≤7 days which records activity counts; consequently, we were unable to interpret or compare this outcome directly to our results. The authors reported 16% of the day was spent inactive [13], which was less than the time spent inactive reported here. The difference could be related to the method of measurement and their younger study population, which had an average age of 69 years of age compared to 79 years in our study. In a smaller study by Mattlage et al., physical activity behaviour of 32 patients in the acute stroke unit over 4 days was measured using an ActiGraph GT3X+ accelerometer [24]. The device records continuous 24 hrs of activity counts of participants. In this study, a cut-off value was used to distinguish between active and inactive states. The participants in the Mattlage et al. study were younger (average age of 55) and spent less time inactive (93% versus 98%, respectively) [24]. Despite differences in the physical activity monitoring devices used, the duration of physical activity recording, method of analysis, and patient clinical characteristics, our data strengthens the overall evidence indicating patients with acute stroke are highly inactive early after stroke.

We explored patient characteristics that might be related to physical inactivity and found a moderate correlation between time spent inactive and stroke severity. We did not find an association between levels of physical activity and age at stroke; however, Strommen et al. reported higher physical activity levels in younger people and those with less severe stroke [13]. Although there seems to be a relationship between stroke severity and inactivity, it is important to note in our study that at admission, 16% of patients were independently mobile but the minimum time spent inactive was 20 out 24 hours. In a longitudinal study by Rand and Eng, physical activity of patients with stroke ($n = 60$) was monitored twice over three full days during their inpatient rehabilitation stay (at admission and after three weeks); they found an increase in steps taken with an increase in time poststroke [25]. Improvements in

Table 1: Participant characteristics and stroke diagnostics.

Demographic	All ($n = 78$)	Monitored ≥3 days ($n = 54$)	Monitored <3 days* ($n = 24$)
Age, median (IQR)	80.5 (70-86)	82.5 (74-86)	72.5 (60-81)
Age, mean (SD)	76 (13)	79 (11)	70.5 (15)
Female/male	37 (47)	26 (28)	11 (46)
Days poststroke, (median (IQR)	1 (1-2)	1 (1-2)	1 (1-1.25)
Premorbid mRS			
Independent (0-2)	68 (87)	46 (85)	22 (92)
Dependent (>2)	10 (13)	8 (15)	2 (8)
Premorbid walking			
Independent nil gait aid	44 (56)	29 (54)	15 (63)
Independent with gait aid	32 (41)	24 (44)	8 (33)
Assistance	2 (3)	1 (2)	1(4)
OCSP classification			
TACI	10 (13)	10 (18)	0 (0)
PACI	22 (28)	14 (25)	8 (33)
POCI	12 (15)	7 (13)	5 (21)
LACI	26 (33)	15 (29)	11 (46)
Haemorrhagic	08 (10)	8 (15)	0 (0)
Side of lesion			
Right	32 (41)	24 (44)	8 (33)
Left	34 (43)	23 (43)	11 (46)
Watershed	1 (01)	1 (2)	0 (0)
Unknown	11 (14)	6 (11)	5 (21)
Stroke severity			
Mild (NIHSS 0-7)	56 (72)	32 (59)	24 (100)
Moderate (NIHSS 8-16)	17 (22)	17 (31)	0 (0)
Severe (NIHSS > 16)	5 (06)	5 (9)	0 (0)
mRS on admission			
Independent (0-2)	4(31)	4 (7)	0 (0)
Dependent (>2)	74 (69)	50(93)	24 (100)
Walking on admission			
Independent	23 (29)	9 (16)	14 (61)
Not independent	55 (71)	45 (84)	10 (39)
Risk factor			
Previous stroke or TIA	24 (49)	16 (29)	8 (33)
Atrial fibrillation	13 (17)	11 (20)	2 (8)
Ischaemic heart disease	21 (27)	13 (24)	8 (33)
Hypertension	51 (65)	36 (65)	15 (63)
Diabetes	11 (14)	5 (9)	6 (3)
Peripheral vascular disease	3 (4)	3 (5)	0 (0)
Hypercholesterolemia	35 (45)	25 (45)	10 (43)

*Excluded from further analysis. All numbers indicate the number of participants (%) unless stated otherwise. IQR: interquartile range; mRS: modified Rankin Scale; OCSP: Oxfordshire Community Stroke Program; TACI: total anterior circulation infarct; PACI: partial anterior circulation infarct; POCI: posterior circulation infarct; LACI: lacunar infarct; NIHSS: National Institutes of Health Stroke Scale; MSAS: Mobility Scale for Acute Stroke Scale ; TIA: transient ischaemic attack.

functional ability, however, were not matched by a similar increase in activity, and activity levels in stroke survivors continued to be less than those in healthy controls [25]. Given that low physical activity levels are a risk factor for stroke, it is likely that a large proportion of stroke survivors were inactive before their stroke. It is therefore also likely that stroke severity is not the main factor that impacts physical activity after stroke. With stroke survivors already having a higher risk of recurrent stroke, it is important to focus on increasing physical activity early after stroke as it

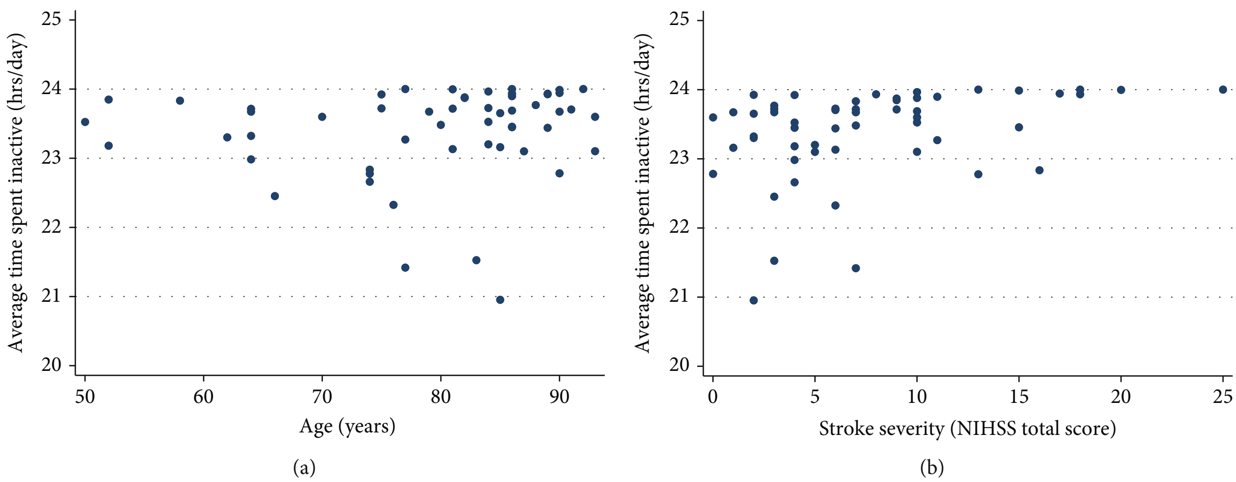

Figure 2: (a) Scatterplot: weak nonsignificant correlation between of time spent inactive (hrs/day) and age (years). (b) Scatterplot: moderate, positive, and significant correlation between of time spent inactive (hrs/day) and stroke severity (NIHSS total score). NIHSS = National Institutes of Health Stroke Scale: a higher score indicates more severe stroke symptoms.

can moderate cardiovascular disease risk including recurrent stroke.

Clinical practice guidelines continue to favour commencing out of bed activity within a few days of stroke unless otherwise contraindicated [6, 26]. What is not clear is the amount of physical activity that should be encouraged after stroke and, more specifically, how recommendations may vary according to cardiovascular risk status and functional impairments to maximise patient outcomes and prevent further stroke. Understanding who may be at a greater risk of inactivity after stroke could help clinicians target important subgroups of patients who need more, or less, support to recommence and sustain physical activity after having a stroke. Early after stroke, other rehabilitation priorities, such as regaining motor function, speech, and swallowing, are likely to take priority, and the presence of comorbid conditions, fatigue, and risk of falling may limit opportunities to engage in physical activity for some stroke patients. Current, albeit limited, evidence suggests a relationship between physical activity and individual characteristics. This highlights that future research needs to consider the broad range of factors that may influence physical activity in the acute stroke environment, including policies that may restrict or encourage physical activity in the ward, and the built environment. The UK “End PJ paralysis” movement (https://endpjparalysis.org/), while not targeted at people with stroke, is an example of a policy shift that could play an important role in changing the attitudes of patients and staff towards physical activity in the hospital environment. No objective data currently exist to demonstrate the possible effect of this policy shift on patient behaviour, but such data would be welcome.

This study is not without limitations. ActivPAL™ records limited details of physical activity which are relevant for the acute stroke population. For example, ActivPAL™ does not distinguish between lying in bed and sitting. For acute stroke survivors, therapeutic training in sitting may be the highest level of function they are able to achieve during early rehabilitation. The time a patient spent engaged in sitting compared to the time spent resting in bed is important to their functional recovery and potentially also to the prevention of medical complications of immobility. While the population in the study are representative of the stroke population in the geographical region, the group were on average older, which might underestimate acute stroke inpatient activity levels and therefore limit the generalisability of our results. As a single site study, the clinical routines, policies, and processes of this unit may vary from those of other stroke units. However, in this relatively large sample, we included stroke survivors across the spectrum of disease severity that demonstrate many of the typical risk factors common to stroke.

5. Conclusion

The findings from this study support a better understanding of physical activity practices of patients with acute stroke and what factors influence this important care practice. There have been few studies that have objectively measured the physical activity behaviour of people with stroke in the inpatient hospital setting. This study highlights the inactivity of stroke survivors in the acute inpatient setting and indicates the more severe the stroke, the less likely the stroke patient is to be active. While there remains uncertainty around when physical activity should commence and how much is helpful for patients with acute stroke, there can be little doubt that the current practises of care result in high levels of inactivity. Future research should focus on the development of interventions that promote physical activity and reduce inactivity that leads to a sustained active lifestyle after stroke.

Data Availability

The physical activity data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

This research was part of Renee Sheedy's PhD studies, see below. All authors were involved as part of their employment NS (Barwon Health) and SK, LC, DC, and JB (Florey Institute of Neuroscience and Mental Health).

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' Contributions

R. Sheedy and S.F. Kramer are shared first authors.

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This work was undertaken by Dr Renee Sheedy as part of her PhD studies who sadly passed away before it could be published. She was granted a Doctor of Physiotherapy (professional doctorate degree), which was well deserved, posthumously by La Trobe University, Melbourne. The authors wish to acknowledge the assistance of her colleagues at Barwon Health and her family who helped acquire the data needed to complete this manuscript.

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