J. Phys. Ther. Sci.
25: 599–604, 2013

Changes in Activity Levels in the First Month after Stroke

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Abstract. [Purpose] To quantify the activity levels of individuals in an acute stroke ward, and to determine if their activity levels change within the first month after stroke. [Methods] In this pilot study, participant activity was monitored prospectively over a single day from 8 a.m. to 5 p.m. on two separate occasions. Individuals with confirmed stroke > 18 years of age and less than 15 days post-stroke at the time of recruitment were eligible for inclusion in this study. Activity was recorded using an electronic device. The first day was scheduled within 15 days and the second at four weeks post-stroke. We looked at the following activity categories: number of transitions, and the times spent lying, sitting and in dynamic activity. [Results] Sixteen individuals were included in this study with a median age of 79.5 years (interquartile range 62.5 to 85). Fifty-six % of the participants had mild, 31% had moderate and 13% had severe stroke, according to the NIHSS score. There were no significant changes in number of transitions, or times spent in dynamic activity and lying and sitting. [Conclusion] Activity levels were low at an acute stroke ward and did not significantly change within the first month.
Key words: Acute stroke, Accelerometry, Physical activity

(This article was submitted Dec. 11, 2012, and was accepted Jan. 11, 2013)

INTRODUCTION

Stroke is one of the major causes of death in the world and might be considered the major cause of complex disability[1)]. Rehabilitation is usually offered to those with disability resulting from stroke. Many rehabilitation programmes include physical training, with the aim of helping individuals with stroke to fully participate in normal activities of daily life independently. Although there is much that remains unknown about the most effective timing and content of physical training programs, it appears that training of physical function is most effective when the frequency and intensity of the training program is high[2, 3)]. A significant challenge in rehabilitation is to provide opportunities for individuals with stroke to continue training (and be physically active) outside of therapist assisted sessions.

Studies commonly report the ability of individuals to complete a range of activities (i.e. using the Functional Independence Measure, the Barthel Index, or other measures of function), rather than the amount of activity an individual may accumulate over time. A systematic review of observational studies found physical activity in hospitalised stroke patients was measured using different methods such as video recordings, therapy reports and behavioural mapping[4)]. These measurement methods all have some advantages and disadvantages. Video recordings allow the collection of accurate real-time data. However, to record the activity of a patient using a video camera is invasive from the viewpoint of patients' privacy, and acquiring patients' consent might be problematic. Therapy recordings provide data on physical activity during therapy sessions, but cannot be generalised to the time spent outside assisted therapy sessions. Several studies have used the method of behavioural mapping to measure physical activity levels of stroke patients in stroke units[5–7)]. Behavioural mapping is a structured observational method that requires a researcher to intermittently observe a participant at set time intervals over a period of time. Although it can be a rich source of data, the method is very time consuming and costly. We are interested in monitoring participants using instrumented methods, which are being more commonly applied to chronic stroke studies[8)]. If a simple system of instrumented monitoring were possible early after stroke, therapists may be able to more readily gather baseline information about activity and monitor the progress of physical rehabilitation over time.

Several studies have used accelerometers to assess physical activity in a stroke rehabilitation setting and in chronic stroke[9–11)]. Furthermore, the majority of studies that looked at physical activity in acute stroke used behavioural mapping[8)]. We are interested in measuring the physical activity early after stroke with a device. The results of a study that looked at classification of therapy activity patterns in acute

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and subacute stroke settings suggest, that the average number of therapy units provided weekly increases with length of stay[12]. This indicates that a change in physical activity levels should be expected early after stroke. Therefore we elected to measure the changes in activity using a device in the first month after stroke.

We are not aware of any studies that have looked at changes in physical activity in the early rehabilitation phase i.e. in the first month post-stroke using an accelerometer. Therefore we aimed therefore to measure changes in activity in the first month after stroke using a device. We chose the use the Positional Activity Logger 2 (PAL2). This device consists of an easy to attach dual axis accelerometer with tilt switches that provides composite information about a person's position and movement over a continuous period of time.

The specific objectives of this study were:

a) to quantify the activity levels of individuals with stroke in an acute stroke ward, and

b) to determine if activity levels change within the first month after stroke

We hypothesised that individuals would become more active over time, both in terms of the frequency with which they move from one position to another throughout the day (i.e. number of transitions), and the level of dynamic activity which was defined as the combined time spent standing and walking. Additionally we wished to determine participants' acceptance of wearing the device in the early phase after stroke, including participants' views on the comfort of wearing the device.

SUBJECTS AND METHODS

This was a pilot observational study in which participant activity was monitored prospectively on two separate occasions over a single day. Baseline activity was measured within 15 days post-stroke with the second measurement at or near four weeks post-stroke. Eligible individuals were those admitted to the acute stroke unit of a major metropolitan hospital in Melbourne, Australia, with confirmed stroke aged over 18 years. We are interested in how active patients are in an acute stroke ward, regardless of the severity of their stroke; therefore, stroke severity was not part of our inclusion criteria. Individuals with severe pre-morbid disability (modified Rankin Scale score of 5)[13], and individuals receiving palliative care were not eligible.

We aimed to collect data from a convenience sample of 20 participants at baseline and follow-up (within four weeks after baseline measurement) which would provide data from a broadly representative stroke sample. In the acute phase of care, it is often difficult to determine discharge destination (e.g. home, nursing home, local or remote) or survival. We therefore planned to recruit a total of 40 individuals with acute stroke with the aim of securing our target. Since this was a pilot study performing a power calculation was not appropriate. All participants or their nominated representatives provided written informed consent prior to participation in this study which was approved by the ethics committee of the Austin Hospital.

Activity was measured using the PAL2 which has been shown to be a valid device for measuring physical activity in Chronic Obstructive Pulmonary Disease (COPD)[14]. Earlier versions of this device have been shown to be valid for measuring patients with hip fracture[15], and the elderly population[16].

The device is a dual axis accelerometer combined with tilt switches, and has a sampling rate of 10 Hz. It is comprised of two parts, a control unit and an auxiliary switch. They were attached to patients' legs with silicon, non slip, laced elastic stretch straps above and below the knee. The straps are lined with Velcro® and can therefore be adjusted to the circumference of the leg. The material of the straps and device are not waterproof and the device was taken off when the participants had a shower.

The combination of information of the two tilt switches, one attached to the upper leg and one on the lower leg, provides information about the physical position of the participant. The combined information of the tilt switches is translated into different positions and activities. The software is designed to register lying, sitting, standing and walking, i.e. when both tilt switches are in a vertical upright position this is recorded as standing, and standing in combination with movement recorded by the accelerometer is recorded as walking.

We combined the standing and walking recordings into one category which we called dynamic activity. The PAL2 activity monitoring device measures the actual time spent (seconds) in each position or activity and the time at which the position/activity occurred, and the number of transitions, which were counted as any time the participant changed from one category to another, e.g. from lying to sitting, or from sitting to dynamic activity. In this study, we were most interested in the amount of dynamic activity participants engaged in and the number of transitions.

We collected demographic information that allowed the sample to be adequately described: age, gender, length of hospital stay, pre-morbid living conditions, pre-morbid disability level (modified Rankin Scale score)[13], stroke side, and the type of stroke (Oxfordshire classification)[17]. Mobility level was measured using the Mobility Scale for Acute Stroke[18], and stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS)[19, 20]. Participants were grouped into mild (NIHSS < 8), moderate (NIHSS, 8 to 16), and severe (NIHSS > 16) stroke categories[21]. To assess if using the device was accepted by patients in the acute phase post-stroke. We asked the participants to indicate if they agreed or disagreed on a 5-point Likert-scale (ranging from strongly agree = 1 to strongly disagree = 5) with the following statement: 'Wearing the device on my leg was comfortable'. Additionally we logged any comments of the nursing staff at the end of the day of observation.

Several times during a week the investigator checked with staff to see if any suitable individuals had been admitted to the acute ward. A total of three participants could be monitored on any one day. Demographic data and baseline measurements were gathered and the first day of monitoring was scheduled as soon as possible after receiving patients' consent within 15 days of stroke.

Before attaching the device to the leg of the participant on the day of monitoring, the device was initiated using the software package (PAL2calcs version February 2010). The device was set to the sampling mode for the duration of nine hours. Staff were made aware that the participant was wearing the device from 8 a.m. to 5 p.m. but were not informed what the device was for. We chose this time frame because it is the most active part of the day and similar time frames have been used in several previous studies[22, 23]. For safety reasons, in cases where participants may have experienced sensory disturbance or paresis of the lower limb, we elected to attach the PAL2 to the unaffected leg. Nursing staff were instructed to take off the device if the participant was taking a shower or during the time participants were scheduled for X-ray or MRI scans. The time the device was taken off and put back on again was logged.

Measurements were repeated at four weeks post-stroke. The same device was used for baseline and follow-up measurement to minimize possible measurement error. We specifically targeted participants attending a rehabilitation facility centre or discharged to home for follow-up. Follow-up measurements could not be planned if participants were discharged to a region that was not accessible to the researchers.

The data from the PAL2 was downloaded via a USB-port onto a computer containing customised software (PAL2calcs version February 2010). The data was calibrated by visual assessment of a data graph and setting thresholds for position i.e. between sitting and standing and lying. Furthermore, when a patient was sitting with straight legs the PAL2 would have recorded this as lying. When the researcher suspected this was the case by looking at the raw data graph, the software allows the researcher to overwrite the record of lying by setting an additional threshold between lying and sitting. The thresholds were set by two investigators independently, and in the case of major differences, consensus was reached through discussion.

After setting the thresholds, Excel files are automatically generated by the PAL2 software. These files contained the following data: times spent lying, sitting, and in dynamic activity in minutes, and the number of transitions. The data from this file was used to quantify the activity levels at baseline and follow-up.

STATA (version 11) was used for the analyses of the data. Descriptive statistics were used to determine the time spent in each activity category at baseline. To determine differences in activity levels between baseline and follow-up we, compared the recordings using the Wilcoxon signed rank-sum test.

We used a variance component model implemented as a random effect multilevel regression analysis model, to explore whether the changes in activity in the first month after stroke were due to within participant variation over time or between participant variations. The model separates the total variability into two components: within subject and between subject. It calculates the proportion (rho) of the overall variability that is explained by the variability between subjects. This proportion ranges between 0 and 1; if the proportion is close to 1, then most of the overall variability is explained by between subject variability; if on the other hand the proportion is close to 0, most of the overall variability is explained by within subject variability over time[24].

Finally we summarised the acceptability data of the participants (Likert-score) and comments of the nursing staff descriptively.

RESULTS

Participants were recruited up to February 2010 at the acute stroke care ward of the Austin Hospital, Melbourne, Australia. Forty-four participants were monitored at baseline, of these participants 20 were followed up. Reasons for being unable to follow-up included: death, discharged to another ward, a private rehabilitation setting (outside of the ethics approval zone), participants declined to be followed up, and discharge to a location outside of the follow-up area limits. For four of the 20 participants that were followed up, the data were not usable due to a software or device malfunction. Therefore the results are based on the complete datasets (baseline and follow-up) of 16 participants. No significant differences were found between the participants that were followed-up (n=16) and the participants that had no follow-up data available (n= 28 data not shown) for the following variables: age, gender, first stroke, type of stroke (infarct or haemorrhage), pre-morbid modified Ranking score, and NIHSS score at baseline. The demographics of the sample are shown in Table 1.

Baseline measurements were conducted with a median of 5.5 days post stroke and an interquartile range (IQR) of 4 to 7. The target for follow-up was set at four weeks post-stroke. To ensure data could be acquired we allowed for a broad time window for follow-up, between the second and fourth week after the baseline measurement. The median time to follow-up was 27 days post-stroke (IQR = 23.5 to 28). Two participants were followed-up at home, and fourteen at a rehabilitation facility.

The baseline activity of the sixteen followed-up participants is described in Table 2. The percentage of time spent in different activity categories varied among the participants. The median time spent in dynamic activity, was 2% of the day. The median number of transitions was 13.5 and varied among the participants, this is represented by the broad IQR of 6 to 29. The largest proportion of the day was spent in a sitting position, which had a median of 52%.

The changes in activity per category are shown in Table 2. We found no significant differences in activity over time across the whole group. However individual variation was apparent. For example, in the majority of individuals (n = 12) the number of transitions increased between baseline and follow-up, ranging from 5 to 73 transitions per day, indicating that over time participants changed position more often over the course of a day. The other four participants showed a decrease in transitions ranging from 5 to 74 fewer transitions per day.

Eleven participants showed an increase in the time spent in dynamic activity per day, ranging from 1 to 35% per day.

Five participants showed a decrease in time spent in dynamic activity ranging from 1 to 44%. Again as a group, the difference in time spent in dynamic activity was not significant.

Most participants (n = 10) spent less time lying down at follow-up compared to baseline, with changes ranging from 2 to 75% per day. However, in six cases participants the time spent lying increased ranging from 34 to 73% per day. And eight participants spent more time sitting at follow-up compared to baseline. The increase ranged from 12 to 74% per day. The decrease in time sitting ranged from 1 to 65%. No significant changes were seen across the whole group.

The proportion of overall variability of the different variables explained by difference between subjects ranged was low and ranged from 0.01–0.18, indicating that overall variability is mostly explained by within subject variability over time (Table 3).

Twenty-seven participants were able to complete the questionnaire regarding the comfort of wearing the device at baseline. Of these 17 participants strongly agreed, four participants agreed, four were undecided, two disagreed and none strongly disagreed. Three participants stated that the straps were too tight and none of the staff commented on the device.

In 4 cases it was impossible to read the data files. We were not able to establish the reason for this data failure.

Table 1. Baseline characteristics of included participants (n = 16)

Variable	Median (IQR) N	%
Age	79.5 (62.5–85)	
Gender		
male	6	38
female	10	62
First stroke		
yes	12	75
no	3	19
unknown	1	6
Side of lesion		
left	6	38
right	10	62
Type		
Infarct	11	69
haemorrhage	5	31
Pre-morbid mRS	0.5 (0–2.25)	
Living conditions pre-stroke		
alone	5	31
with someone	10	62
other	1	6
NIHSS		
Mild <8	9	56
Moderate (8–16)	5	31
Severe (>16)	2	13
Total score	5 (3–16)	
MSAS Gait	2 (1–4.25)	
MSAS Total	14 (10, 23.5)	
Length of stay (days)	13.5 (10.3–19.3)	

mRS = premorbid modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, MSAS = Mobility Scale for Acute Stroke

DISCUSSION

In this study we aimed to record changes in activity over the first month after stroke using an accelerometer. We quantified activity levels of individuals with acute stroke and found that the time spent in dynamic activity was low. The majority of participants spent most of their active day in a passive state, namely sitting or lying. This result is similar to those of other studies in which individuals with acute stroke were monitored using behavioural mapping and were found to spend over 50% of their active day lying in bed[6]. However, individual variation across all activity categories was high.

We also evaluated the changes in physical activity in the first month after stroke and found that there were no significant changes in number of transitions, and the time spent in dynamic activity, lying and sitting. At baseline patients' physical activity was recorded in an acute stroke ward, and at follow-up patients had made the transition to a rehabili-

Table 3. Proportion of overall variability of different activity categories explained by between subject differences

Change variable	Rho
Number of transitions	0.18
Time spent in dynamic activity	0.01
Time spent lying	0.07

Rho = proportion of overall variability explained by between subjects differences

Table 2. Activity levels and differences between baseline and follow up

Category	Baseline activity median (IQR)	Follow-up activity median (IQR)	Difference median (95% CI)
Number of transitions	13.5 (6–29)	23 (11–50)	12 (0.17–34)
% of time spent in dynamic activity	2 (1–5)	3 (1–10)	2 (−1–4)
% of time spent lying	36 (28–62)	40 (10–83)	−10 (−34–38)
% of time spent sitting	52 (36–65)	55 (16–75)	−2 (−36–30)

* Wilcoxon signed rank sum test two tailed significance level set at $p < 0.05$

tation ward or to home. We expected that activity levels would be higher in the follow-up settings. However, in some cases dynamic activity was lower and time spent lying was higher. We looked to see whether those patients who became more active were different from those who became more sedentary over time, but found no specific characteristics such as older age or greater stroke severity that might have explained our findings. It is known that functional recovery after stroke is most rapid in the first months after stroke[25]. A review found that several factors are associated with walking within 30 days post-stroke, but the data from prognostic research in this area is limited[26]. Therefore, it is very hard to predict which patients will be active or not.

Changes over time were small at best. A median increase of 2% which corresponds with approximately 11 minutes of dynamic activity does not seem to be clinically relevant. However we neither know how much activity is needed nor how much rest is needed to improve functional status in the acute phase after stroke. Additionally, the variation of activity level was greater at follow-up than at baseline, indicating that earlier after stroke, differences among the patients were smaller. The physical activity of all patients was recorded in the same acute ward at baseline, whereas follow-up measurements were made at different rehabilitation facilities, and two patients were followed up at home. This suggests the possibility that other factors such as environment may influence activity levels after stroke. However, only a small percentage of variances of changes in activity of the different variables were explained by between patient differences (1–18%) indicating that most of the variance was explained by within patient differences i.e. time.

In acute care we know that patients will spend a lot of time in bed and using a device can be uncomfortable. Additionally, most devices will not distinguish between sitting and lying. In acute care patients have diagnostics test and procedures and devices need to be taken off for most of the procedures. Therefore this is one of the few studies that set out to test the acceptability of using a device in acute care. As such, our data produces a snapshot of activity.

The accelerometer we used in this study is an easy to attach device that can distinguish between lying and sitting. Most of the study subjects did not have any problems wearing the device over a nine hour period. This bodes well for future studies using accelerometry in acute stroke populations.

Using a device in acute care can be more challenging than in other settings. The length of stay in an acute stroke ward is in most cases fairly short. The days that patients are admitted and discharged are not suitable for monitoring. Furthermore, in acute setting patients undergo multiple testing which requires a device to be removed. Again, these days are generally not suitable for monitoring. That leaves only a few days during the hospital stay that are available for monitoring physical activity. Therefore, an acknowledged limitation of this study is that we elected to record over a single day. Additionally, this study might have been unable to detect a significant change over time in activity levels. Also, since the data is based on a small sample size, the results must be interpreted with caution. Furthermore, the follow-up data was recorded at a rehabilitation ward, therefore the results of this study cannot be generalised to stroke patients that are discharged to other settings.

This pilot study showed that activity levels in the first month after stroke are low. The majority of patients' time was spent lying or sitting. Using an accelerometer to record activity in an acute ward and at a rehabilitation facility was acceptable to the patients. Patient related factors only partly explain levels of dynamic activity early after stroke and future research should consider the effect of environment and ward policy on physical activity.

ACKNOWLEDGEMENTS

We would like to thank staff of the Austin acute care ward and the rehabilitation ward at the repatriation hospital for their advice and support during this study. We would also like to thank Michael Gorman the producer of the PAL2, who made the PAL2 devices available for us to use in our study, and for his support and technical advice during the study.

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