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Recovery of ambulation activity across the first six months post-stroke

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ABSTRACT

Stroke survivors commonly adopt sedentary activity behaviours by the chronic phase of recovery. However, the change in activity behaviours from the subacute to chronic phase of stroke is variable. This study explored the recovery of ambulation activity (volume and bouts) at one, three and six months after hospital discharge post-stroke. A total of 42 stroke survivors were recruited at hospital discharge and followed up one, three and six months later. At follow-up, ambulation activity was measured over four days using the ActivPAL™ accelerometer. Measures included volume of activity and frequency and intensity of ambulation activity bouts per day. Linear mixed effects modelling was used to determine changes over time. There was wide variation in activity. Total step counts across all time points were below required levels for health benefits (mean 4592 SD 3411). Most activity was spread across short bouts. While most number of bouts was of low intensity, most time was spent in moderate intensity ambulation across all time points. Daily step count and time spent walking and sitting/lying increased from one month to three and six months. The number of and time spent in short and medium duration bouts increased from one to six months. Time in long duration bouts increased at three months only. Time spent in moderate intensity ambulation increased over time. No change was observed for any other measures. In future, it would be valuable to identify strategies to increase engagement in activity behaviours to improve health outcomes after stroke.

1. Introduction

Ambulation, or walking activity, is known to have beneficial effects on physiological, psychological, sensorimotor, strength, endurance and functional recovery after stroke [1]. However, by the chronic phase of recovery, stroke survivors commonly adopt sedentary activity behaviours [2]. For example, after stroke, daily step counts are reported to range from 1400 [3] to 6195 [4] steps/day, indicating that the overall volume of activity after stroke is mostly below that required for general health benefits (i.e. 10,000 steps per day) [5]. However, observation of change in ambulation activity behaviours from the subacute (24 h to 6-months post-stroke) to the chronic phase (>6-months post-stroke) of stroke recovery is limited and variable [4,6,7].

Only three studies have reported on the changes in ambulation activity during the first six months following stroke. These studies report a range of findings, from no change in daily step counts across six weeks after hospital discharge post-stroke [4], to improvements of approximately 1200 steps/day (80% increase) across twelve weeks after hospital discharge [6,7], with little change in daily ambulation activity after this time [7]. This variation in the literature is likely due to many factors, including the devices used, the time points chosen and measures used to characterise activity.

When measures are examined, device-based measurement of ambulation activity after stroke has traditionally been characterised by measures of volume such as daily step counts [3,4,7,8], activity duration [9,10] and estimated energy expenditure [7]. However more recently, the importance of capturing the spread of activity across the day has been highlighted [11]. 'Ambulation activity bout' metrics provide detailed information regarding variations in activity across the day [12,13] and are used to investigate characteristics such as the frequency and intensity of ambulation activity after stroke [11–13]. To date, only one study has investigated changes in ambulation activity bouts over time, and this was limited to the first six weeks following stroke [4]. Greatest recovery is observed in the first three to six months

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following stroke [14], thus investigation of how characteristics of ambulation activity change across this timeframe is required. This may assist in understanding how stroke survivors develop sedentary activity behaviours [2]. Thus, the purpose of this study was to characterise ambulation activity (volume and bouts) and investigate how it changes across one, three and six months after hospital discharge post-stroke.

2. Methods

This was a prospective, longitudinal observational study, approved by institutional ethics committees. All participants provided written informed consent.

2.1. Participants

Participants were recruited consecutively from the acute stroke and rehabilitation units at The Prince Charles Hospital, Brisbane, Australia, if they were (1) diagnosed with a stroke within the preceding 4 months; (2) aged >18 years and (3) discharged into the community. Individuals were excluded if they had (1) another neurological condition or co-morbidities that limited ambulation prior to stroke; (2) unstable medical conditions, chest pain, heart attacks, angioplasty or heart surgery in the previous three months; (3) were discharged to a residential aged care facility; (4) moderate to severe expressive or receptive communication difficulties; or (5) scored <24/30 on the Mini Mental State Examination (MMSE) [15].

2.2. Procedures

Participants were recruited prior to discharge from hospital. Demographic and routine clinical discharge measures of walking capacity, including comfortable gait speed over 10 m [16] and distance walked over 6-min [17] were collected. At one, three and six months, participants returned for a follow-up assessment where an accelerometer, the ActivPAL™ (PAL Technologies Ltd©, Glasgow, UK) was applied to record usual daily ambulation activity. The ActivPAL™ accelerometer was worn continuously by participants for four complete days, which is deemed sufficient for measurement of habitual activity [18]. It was encased in a waterproof casing and affixed to the skin in the middle of the anterior thigh of the non-hemiparetic leg. The ActivPAL™ has been deemed valid and reliable in people following stroke [19].

2.3. Measures of ambulation activity

Measures of ambulation activity were categorised according to volume, frequency and intensity and based on previous studies in stroke populations. An *'ambulation bout'* was defined as any 15-s data epoch with at least two steps [4,12,13]. *Volume* of ambulation activity was determined using measures of total number of steps per day and total time in minutes per day spent sitting/lying, standing, walking and in upright positions. *Frequency* of ambulation activity was determined using total number of bouts and time in minutes spent at each ambulation bout duration (short, medium and long) [4,11]. Ambulation activity bout duration was defined as – short: any bout with <40 steps; medium: any bout with 41–300 steps; and long: any bout with >300 steps [11]. *Intensity* of ambulation activity was determined based on the number of bouts and daily time spent in ambulation activity bouts of low, moderate and high intensity [4]. Ambulation activity bout intensity was defined as – low: any bout with a cadence of <30 steps/min; moderate: any bout with a cadence of 30–80 steps/min; and high: any bout with a cadence of >80 steps/min.

2.4. Data analysis

A priori power analysis indicated that a sample size of 32 stroke survivors would be sufficient to determine change in the number of steps taken per day [6] with a power of 0.8 and alpha of 0.05. Thus, a 42 stroke survivors were recruited (allowing for 10 dropouts). Activity data were downloaded from ActivPAL™ devices using PAL software. A customised MATLAB (Mathsworks, Natick, MA) program was used to calculate daily ambulation activity measures, with averages per day used in the final analysis.

Data were screened and when variables did not meet assumptions of normality, ambulation activity data were transformed using the square root/log transformation (positive skew), or reverse square root/log function (negative skew) [20]. The sample was characterised by calculating means and standard deviations for all continuous variables and frequency for all categorical data. Linear mixed effects models were used to determine changes in walking capacity over the three time points [21]. To determine differences in characteristics between included participants and dropouts, Mann-Whitney U tests were used for non-parametric and ANOVAs for parametric data.

Descriptive statistics were completed for all volume, frequency and intensity measures for all time points. Linear mixed effects models were used to test for changes in activity across one, three and six months [21]. Models were adjusted for age and discharge gait speed. Age has been recognised as a significant predictor of functional recovery [22], and gait speed is a predictor of free-living activity in people with chronic stroke [23]. Significance was set at $p < 0.05$ and SPSS 21.0 was used for all statistical calculations.

3. Results

3.1. Participants

Forty-two stroke survivors were recruited at hospital discharge. Prior to one month follow-up, six participants withdrew or were lost to follow-up. Thus, a total of 36 participants were included in the final analysis. Flow of participants through the study is presented in Fig. 1. No significant differences were observed between participants included in the analysis and those who withdrew or were lost to follow-up ($p \geq 0.063$) at all time points.

Characteristics of participants included in the final analysis are detailed in Table 1. There was no change in gait speed ($p > 0.117$) or endurance ($p > 0.067$) across all time points.

3.2. Characteristics of ambulation activity

Untransformed measures of ambulation activity are presented in Table 2. Stroke survivors demonstrated a range in all measures of activity at all time points. There were no significant differences in the number of weekdays and weekends that fell within the measurement period across all time points ($p > 0.057$).

Stroke survivors took on average 4600–5000 steps per day, with a range of 148–17,686 at the three time points (see Table 2). A majority of their day was spent in sitting/lying positions (~19 h), spending just around one hour walking (ranging from 10 min to 3 h) and 4 h in upright positions (ranging from approximately 2–8 h) per day.

Ambulation activity was spread across an average of 142–151 bouts per day (see Table 2). Most ambulation bouts (85%) were short in duration (<40 steps) at all time points, with 15% of all bouts being of medium duration (40–300 steps) and only 1–2 long bouts taken each day. At all time points, around 14–16% of stroke survivors did not engage in any long ambulation bouts across the four days. A similar pattern was observed for proportion of time spent in short, medium and long duration bouts per day across the