

# Predicting Daily Use of the Affected Upper Extremity 1 Year after Stroke

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*Background:* The ultimate goal of upper extremity (UE) stroke rehabilitation is for the individual with stroke to return using their arms and hands during daily activities in their own environment. No studies have monitored arm use as individuals with stroke transition from rehabilitation to the home setting. This longitudinal study compared the functional ability and daily use of the affected UE of individuals with stroke between discharge to home and 12 months after stroke and predicted the UE daily use 12 months after stroke. *Methods:* Participants were assessed on discharge to home from rehabilitation and at 12 months after stroke. UE daily use was measured by wrist accelerometers and self-report by the Motor Activity Log (MAL). Multivariate logistic regression models were used to predict UE daily use 12 months after stroke. *Results:* The UE functional ability improved significantly from discharge to 12 months after stroke. The amount of self-report UE daily use significantly improved ( $z = -2.9, P = .004$ ), but accelerometer activity counts did not ( $z = -0.15, P = .88$ ), and the daily use of the nonaffected UE was 3 times more than the affected UE. After controlling for age and accelerometer daily use on discharge, UE variables of movement, function, dexterity, and strength accounted for an additional 10.9%-13.6% of the variance for accelerometer readings. After controlling for gender and MAL daily use on discharge, UE variables accounted for an additional 7%-12% of the variance for the MAL. *Conclusions:* UE daily use 12 months after stroke is very limited despite the motor and functional improvement. Enhanced motor and functional ability at discharge predicts more UE daily use at 12 months after stroke. Interventions that monitor and encourage these individuals to use their UE are required to ensure that functional gains translate to daily use. **Key Words:** Accelerometers—stroke rehabilitation—prediction—recovery.  
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## Introduction

The upper extremity (UE) is mildly to severely affected in approximately 70% of the individuals who sustain a stroke.<sup>1</sup> Despite the fact that treatments are provided to improve the UE during the rehabilitation process, most of these individuals remain with a nonfunctional affected

UE.<sup>1,2</sup> More so, in many cases, despite the improvement in the ability to move the UE, the affected UE is still not used for daily function.<sup>3</sup>

The most powerful predictors of UE recovery reported in a recent meta-analysis<sup>4</sup> were baseline level of UE impairment and function and intact motor-evoked or

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somatosensory potentials. Six-month recovery was predicted by active range of motion,<sup>2,5,6</sup> muscle strength, and 2-point discrimination<sup>7</sup> measured within the first 4 weeks after stroke. In these studies, recovery was defined by motor or functional ability but did not provide an estimate of how much the affected UE was actually used in daily life. There is a growing recognition that there is a disparity between the motor ability and actual real-world arm use<sup>8</sup> where individuals who have the ability to move their stroke-affected arm and hand but do not use this arm for daily activities.

Arm use has been assessed by a limited number of observations or by self-report questionnaires such as the Motor Activity Log (MAL)<sup>9</sup> and the Rating of Everyday Arm-Use in the Community and Home.<sup>10</sup> However, these are subject to recall bias and may not be suitable for all individuals, especially those who experience language or cognitive deficits. Recently accelerometers have been used to measure the extent and intensity of UE movement in the home and community setting. Accelerometers provide a reliable and objective way to assess real-world UE function of individuals with stroke.<sup>11-15</sup>

Cross-sectional studies have found that early post-stroke UE wrist accelerometer measures correlate to stroke severity<sup>16</sup> and motor impairment of the affected UE.<sup>16,17</sup> More so, correlations have been found between accelerometer readings to the self-report MAL ( $r = .81-.90$ ) for 169 individuals 3-9 months after stroke.<sup>13</sup> In addition, accelerometer activity of the affected UE was found to be an excellent predictor for prolonged disability as assessed in 129 individuals using the modified Rankin Scale score 3 months after stroke<sup>18</sup> and to the Rating of Everyday Arm-Use in the Community and Home scale ( $\rho = .61$ ) for 68 individuals with chronic stroke.<sup>10</sup>

No studies have monitored arm use as patients with stroke transition from the hospital to the home setting. To guide our treatment in a cost-effective way, it would be useful to predict, which patients are more likely to use their arm and hand when they return to their home and community setting. Consequently the aims of our study were as follows: (1) to compare the function and daily use of the upper extremities of individuals with stroke between the time of discharge to home and 12 months after stroke and (2) to predict the daily use of the affected UE 12 months after stroke based on assessments undertaken at the time of discharge to home. Daily use was measured by wrist accelerometers and by the MAL.

## Methods

The recruitment and data collection of these subjects have been previously described.<sup>8</sup> In a previous report, we described how daily arm use after stroke did not increase over the inpatient hospital stay,<sup>8</sup> whereas this cur-

rent report provides opportunity to follow a subset of these individuals longitudinally into the home and community setting.

### Population

In brief, adults 19 years of age and older who were admitted to 1 of 2 rehabilitation settings because of a stroke volunteered to participate in the study. Participants were excluded if they had a neurologic condition other than stroke or if they had communication or cognitive difficulties that prevented them from understanding and signing the consent form. This study was approved by the local university and hospital ethics boards, and all eligible participants provided written informed consent before participating in the study.

### Tools

To characterize our population at the time of discharge, we used the Star Cancellation Test from the Behavioral Inattention Test, which is a valid screening test for unilateral visual neglect.<sup>19</sup> The Mini Mental Status Examination<sup>20</sup> was used to screen for general cognition. The presence of depressive symptoms was obtained using the Center for Epidemiologic Studies Short Depression Scale-10 (CES-D).<sup>21</sup> The functional ability of the individuals performing basic activities of daily living was assessed using the Functional Independence Measure (FIM), which has been found to be reliable and valid when used with individuals with stroke.<sup>22</sup> The total FIM score ranges from 18 to 126 points.

### Daily Arm Use

To provide a continuous, objective measure of UE daily use, participants wore 2 Actical accelerometers (Actical; Mini Mitter Co, Bend, OR) attached to each wrist with a standard watch strap for 3 consecutive weekdays. In addition, they wore an accelerometer on the affected hip to measure walking steps to eliminate arm swing movement during walking. The Actical accelerometer is a small ( $28 \times 27 \times 10$  mm) triaxial, light (17 g), and waterproof accelerometer. It has a frequency range of .3-3 Hz, is sensitive to .05-2.0 G-force, and samples at 32 Hz. The accelerometer records, rectifies, and integrates acceleration over 15 seconds epochs as activity counts. Each daily record was visually examined to ensure integrity of the signal (eg, activity on morning rise, intermittent activity through the day, no irregular and/or unexplainable activity). Daily use of each arm was calculated as the total number of activity counts (without arm swing movements during walking) over the 3 days divided by 3. Because Actical wrist accelerometers can monitor UE movements for 11 days, daily use of the UEs can be monitored in the individual's home setting. Actical wrist activity counts have been shown

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