Steps After Stroke
Capturing Ambulatory Recovery

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Background and Purpose—Nearly two thirds of stroke survivors have deficits impairing ambulatory recovery. Conventional mobility outcome measures such as timed walks and functional independence measure (FIM) do not quantify free-living ambulatory behavior. This study compared step activity monitoring (SAM) with established instruments to assess ambulatory recovery across the outpatient subacute stroke rehabilitation phase.

Methods—We measured FIM mobility subscale, SAM-derived daily steps, Stroke Impact Scale (SIS) mobility scores, and timed walks in 11 subjects after discharge from inpatient rehabilitation and again 3 months later.

Results—Significant improvement was measured in free-living step activity (mean gain 80%; $P=0.001$) but not with timed walks ($P=0.4$), FIM ($P=0.08$), or SIS mobility scales ($P=0.3$).

Conclusions—Microprocessor-linked SAM is a sensitive indicator of ambulatory recovery that measures improvements not captured by other conventional outcome instruments. **(*Stroke*. 2005;36:1305-1307.)**

Key Words: outcome ■ stroke

A poststroke rehabilitation goal is to resume ambulation in home and community.[1] Although commonly used, survey-based measures of mobility recovery and timed walks may not capture elements of ambulatory behavior or mobility-dependent social participation that indicate recovery. Trained observer-rated measures, such as the Functional Independence Measure (FIM), although sensitive in severe stroke, demonstrate a ceiling effect in patients with mild to moderate disability still requiring assistance.[2] A method to measure functional ambulatory changes that account for differences in stroke severity, reported and actual performance, and daily patterns is needed.

Portable microprocessor-linked step activity monitoring (SAM; Cyma Corporation) provides an accurate, reliable method for quantifying ambulatory activity across a broad range of gait deficits (≥97% accuracy with hand-tallied step counts; $P<0.001$).[3–6] We investigated the utility of SAM to determine profiles of ambulatory activity across the subacute outpatient rehabilitation period and compared the sensitivity of SAM with conventional outcome instruments to measure ambulatory recovery.

Methods

Community-dwelling men and women with mild-to-moderate poststroke hemiparetic gait deficits were recruited at discharge from inpatient rehabilitation. Participants provided informed consent according to approved institutional review board procedures. Exclusion criteria protected safety and controlled for extraneous factors impacting ambulatory activity.

Quantifying ambulatory activity with SAM, self-selected floor-walking velocity (SSFWV),[7] FIM,[9] and Stroke Impact Scale (SIS) mobility[7] subscales was conducted 2 weeks after rehabilitation discharge and repeated 3 months later. The timed 30-foot walk is a simple and robust technique to evaluate ambulatory function in a variety of neurological conditions. SSFWV is recognized as a criterion standard index of hemiplegic motor recovery and is a key indicator of ability to manage household distances.[7,8]

The FIM is widely used in rehabilitation to evaluate mobility; 2 items comprise a mobility subscale measuring domains of basic ambulation and stair climbing. The FIM subscales have established item internal consistency in 96.9% of tests and item-discriminant validity in 100%, with reliability coefficients ranging from 0.86 to 0.97.[9] FIM is sensitive in patients with severe stroke, but a ceiling effect has been noted in patients with more mild to moderate disability who still require a level of assistance.[2]

The SIS is a 64-item self-report scale designed to assess 8 functional domains, with established reliability and validity.[10] The mobility subscale is comprised of 10 items that query the subject regarding balance during sitting, standing and walking activities, transfers, ambulation, and stair climbing. The SIS was highly correlated with scores on FIM mobility (0.83), the Duke Mobility Scale, (0.83), and the Short Form 36 (SF-36) Physical Function Q3 (0.84).[10]

Data were analyzed using SPSS version 10.0.[11] Simple regression was used to evaluate the relationships between the mobility outcomes measures. Paired t tests were used to examine the significance of change in SSFWV and SAM between baseline and 3 months. Wilcoxon signed-rank tests were used to compare change in FIM stair, ambulation, and total mobility subscales, and SIS mobility subscale scores.

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Measures of Mobility Outcome and Change Across 3 Months

	No.	Time 1	Time 2	Δ % change	*t*
SAM	19	1536±106	2765±1677*	+80%	−4.01
FIM mobility§	18	10.8 ± 2.1	11.3 ± 2.5‡	+5.1%	−2.05
Ambulation	18	5.8±0.8	5.9 ± 1.0	+2.2%	−0.70
Stairs	18	5.0±1.3	5.4 ± 1.5†	+7.7%	−2.41
SIS mobility	15	32±5.4	34.6 ± 7.3	+8.1%	−1.13
30-foot walk (m/s)	14	0.37±0.13	0.40±0.17	+6.5%	0.95

Data are mean±SD.

*$P<0.001$.

†$P<0.05$.

‡$P=0.08$.

§FIM mobility subscale 4 to 6 on either item indicates assistance required for task.

Results

Sixty patients were screened, 21 enrolled, and 19 completed the study. Exclusions included gait deficit too severe (n=10), cognitive or communication impairment (n=21), or travel issues (n=8). Participants' ages ranged from 48 to 91, with a mean of 68 (±12.8) years. Ten were males, 11 white and 10 black, with side of hemiparesis evenly split. Mean FIM, SIS, SSFWV, and SAM-derived daily step counts at baseline and at the 3-month time point are shown in the Table. Variations in sample size reflect either missing measures or inability to perform test.

Only SAM-derived daily step counts changed significantly across the 3-month outpatient rehabilitation phase, averaging an 80% increase, indicating that SAM is sensitive to changes in ambulatory activity. Although there was a trend toward improvement in FIM mobility subscale scores ($t=-2.05$; $P=0.75$), this was attributable to a significant increase in the FIM stair climbing item ($t=-2.41$; $P=0.038$). SAM was strongly related to FIM mobility scores on cross-sectional analyses at baseline ($r=0.52$; $P=0.016$) and 3 months later ($r=0.62$; $P=0.006$).

Discussion

SAM is a sensitive index of ambulatory recovery across the subacute stroke rehabilitation period, detecting an 80% mean improvement in ambulatory activity profiles across the first 3 months at home. Traditional benchmark measures did not show significant change across the same time period. Hence, SAM documents elements of ambulatory recovery in patients with hemiparetic gait deficits that are not captured by other conventional mobility outcome instruments.

Most commonly used mobility outcome instruments rely on patient report or observer-rated standardized scales, or use laboratory-based measures such as timed walks and gait biomechanics to characterize locomotor performance. Conventional instruments do not measure free-living ambulatory behavior or mobility-driven social participation. We document tremendous heterogeneity in ambulatory behavior profiles that occurs independent of significant change in gait speed.

Furthermore, mean step activity profiles in stroke patients demonstrate the lowest activity profiles reported.[12] Although step counts were low, repeated measures demonstrated statistically and clinically significant increases not reflected in other outcomes instruments, suggesting that SAM reveals unique elements of physical and participatory recovery.

We observed significant gains in FIM stair climbing but not in FIM ambulation. Our data reveal differences in recovery of ambulation versus stair climbing, suggesting the composite FIM mobility subscale score may not fully characterize early poststroke ambulatory recovery. Although regression analysis shows FIM scores are related to SAM-derived step counts, the latter is substantially superior to detect change across the subacute period.

The revelation that stroke patients continue to progress in their ambulatory recovery during a time after discharge often described as a plateau suggests that the opportunity exists to further optimize recovery through additional rehabilitation interventions. SAM may prove a valuable index of ambulatory response to therapies. Step activity also gives insight into behavior between structured therapy sessions. Hour-by-hour activity profiles can provide motivational feedback, which may reinforce ambulatory behavior and enhance stroke survivors' self-efficacy for ambulation, promoting social participation and mobility outcomes.

The study was limited by a small sample size. Some subjects were still receiving home or outpatient therapy. However, regardless of therapies, SAM successfully detected ambulatory activity changes in the absence of significant change in other benchmark mobility measures.

Conclusions

In individuals with mild–moderate hemiparetic gait after stroke, SAM provides an accurate measure of ambulatory behavior across the subacute rehabilitation period. SAM may prove useful in evaluating rehabilitation outcomes by augmenting conventional instruments. In addition to the utility of step monitoring data as an outcome measure, future studies should seek to determine whether it would be useful as a behavioral reinforcement tool for patients and therapists to optimize ambulatory recovery and social participation after stroke.

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