

SUPPLEMENTAL DIGITAL CONTENT file for:

“Monitoring Community Mobility with Global Positioning System Technology after a Stroke: a Case Report”

Past medical history and review of systems:

The patient had no children, but had the support of his wife and brother. His brother came in from out of town for several weeks to assist with his rehabilitation following discharge. He reported that he drank alcoholic beverages occasionally and did not smoke and or use drugs other than prescription medications. Several months before the stroke he joined a gym and began working with a personal trainer, performing strengthening and conditioning exercises 2-3 times/week. The patient was taking the following medications: lisinopril, hydrochlorothiazide and sertraline hydrochloride. He was 1.7 m tall, weighed 70.5 kg and had a body mass index of 24.4.

Examination and In-Patient Rehabilitation Data:

He was alert and cooperative and able to follow most one step commands. Active and passive range of motion (ROM) were grossly assessed using modifications of standard positions. The patient had normal active ROM in the right, but no active ROM in the left upper and lower extremity. Passive ROM was within normal limits for both the right and left upper and lower extremity except for ankle dorsiflexion on the right, which was limited to neutral. Manual muscle testing was not performed due to reliability concerns given his hemiparesis; however, it was noted that he had very little active motion or voluntary strength on the left side both in the upper and lower extremity. The Functional

Independence Measure (FIM) test was administered at the time of evaluation and discharge and is shown in Digital Data Content table 1. The Six Minute Walk Test (SMWT) and Timed Up and Go Test could not be administered at initial evaluation secondary to the patient's dependence in mobility and standing, but these were collected at discharge.

Table 1: Functional Independence Measure, Motor Subscale Scores		
FIM category	Admit	Discharge
Ambulation	1	5
Bed Transfer	3	6
Toilet Transfer	3	6
Stairs	0	5
Social Interaction	7	7
Problem Solving	7	7
Memory	7	7
Comprehension	7	7
Expression	7	7
Bladder- Assist	7	7
Bowel	7	7
Bladder	7	7
Bowel	7	7
TOTAL	70	85
Functional Independence Measure (FIM), motor subscale scores represent the rating of function on the selected subscale from 0-7 with 0 being complete dependence and 7 being complete independence. The maximum possible score for the motor subscale is 91.		

At admission to the rehabilitation unit, the subject's FIM rating of ambulation was a 1 and at discharge he had improved to 5 and was able to ambulate with a quad cane and rigid ankle-foot orthosis with stand by assistance. At discharge he completed 73 meters in the SMWT and performed the TUG in 58.65 seconds. The SMWT has been shown to be reliable and moderately to strongly associated with gait speed ($r = 0.89$)¹ and the TUG has been shown to be a reliable and sensitive measure of fall risk in patients with a stroke

or with movement dysfunction.^{2,3} His Berg Balance Score at discharge was 35 out of a possible 56 points (see table 2 of main document). This test has been shown to have good inter (ICC = 0.98) and intra-rater (ICC = 0.97) reliability for post-stroke older adults.^{4,5} At discharge, he was administered the Mini-Mental State Exam (MMSE) to help in establishing that he would be able to operate the study equipment. The MMSE has been shown to be sensitive to detection of dementia, but also have good negative predictive value.^{6,7} He scored 29 out of 30 on the MMSE.

GPS and Accelerometer Reliability:

GPSt is now routinely used in a diverse set of applications from farming to transportation planning to exercise science. The reliability of GPSt for the measurement of community mobility post-stroke has not been investigated. However, from a purely technical perspective, GPS devices in general are sufficiently precise to track an individual's movement within the community. Rodríguez et al. 2005⁸ reported static reliability of a GPS unit to be very accurate with 99.4% of recorded observations falling within 15m of a known reference (geodetic) point. With respect to dynamic reliability, it is well known that being indoors, proximal to buildings or under a canopy such as trees all increase the variability of the GPS signal. Often, supplementation of mobility data with accelerometry can resolve this issue, at least with respect to ambulation measurements. In this connection, GPS calculations of walking have been shown to be highly correlated with more direct measures of walking speed⁹⁻¹² and very accurate with a less than 2% error in detecting walking speed in a sample of community dwelling older subjects¹³. Unlike accelerometry, GPSt can be used to determine where the subject is located, and

how they navigate to the meaningful events and places in their lives. In this context, GPSt is very accurate and has been shown to identify locations and travel events when subjects forget to document such locations in an event log¹⁴⁻¹⁶.

According to the manufacturer (GlobalSat, DG-100 Data Logger User Manual Version 1.21, available at: <http://www.gpscentral.ca/manuals/gs-dg100.pdf>) the DG-100 Data Logger has an accuracy of 10 meters when operating under standard conditions and 1-5 meters when the Wide Area Augmentation System (WAAS) is enabled, as was used for this study. In addition, the accuracy of velocity measurements is listed as 0.1 m/sec under standard conditions. Several studies^{13,17,18} have found that error was very low in walking tests over a known distance with various GPS units.

We conducted a separate series of tests in order to examine the accuracy, intra-operator/instrument and inter-operator/instrument reliability of GPSt when monitoring human movement around a suburban environment. For these tests, 5 subjects without neurological injury provided written, informed consent and the protocol was approved by the University IRB. In the first test, 4 subjects walked a 1-mile path around a university campus that was calibrated with a race measurement wheel to 1.032 miles in length. These studies were carried out with a different GPS unit, the Forerunner 205 unit (Garmin, Inc.), but the logging frequency was similar for both units and both were WAAS-enabled. The subjects in the reliability study wore two GPS units as they completed 5 separate circuits on the path. In a separate test, one subject wore one GPS

unit continuously for two weeks. This subject was asked to provide "target" addresses in the community where she anticipated visiting and to keep track of the number of times the targets were visited in a log.

For the inter and intra-operator/instrument reliability tests, the average distance measured with GPS#1 and #2 was the same (1.03 ± 0.02 miles) and were not significantly different from the calibrated distance. The interclass correlation coefficient for walking speed was 0.88, indicating relatively good reliability between the units in recording the average speed. For the subject who wore the GPS for two weeks continuously, analysis of the GPS signal indicated she visited two target destinations on several occasions each week and these were verified by her log. These results suggest that GPS provides a reliable measure of community movement.

The accuracy of the ActiGraph accelerometers has been shown to be variable depending on walking speed. Two studies^{19,20} indicated good accuracy at speeds ≥ 0.9 m/sec, but several other studies^{13,21,22} indicated that while it is accurate above 0.9 m/sec, it underestimates step counts for speeds slower than this.

Supplemental Digital Content References:

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