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Prediction of discharge walking ability from initial assessment in a stroke inpatient rehabilitation facility population

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Abstract

Objective: 1) determine which clinical assessments at admission to an IRF most simply predict discharge walking ability, and 2) identify a clinical decision rule to differentiate household versus community ambulators at discharge from an IRF.

Design: Retrospective cohort study

Setting: Inpatient Rehabilitation Facility (IRF)

Participants: Two samples of participants (n = 110 and 159) admitted with stroke.

Interventions: A multiple regression determined which variables obtained at admission (age, time from stroke to assessment, Motricity Index, somatosensation, Modified Ashworth Scale, Functional Independence Measure (FIM), Berg Balance Scale, 10 m Walk Speed) could most simply predict discharge walking ability (10 m Walk Speed). A logistic regression determined the likelihood of a participant achieving household (<0.4 m/s) versus community (≥0.4-0.8; >0.8 m/s) ambulation at time of discharge. Validity of the results was evaluated on a second sample of participants.

Main Outcome Measure: Discharge 10 m Walk Speed

Results: Admission Berg Balance Scale and FIM walk item scores explained the majority of the variance in discharge walk speed. The odds ratio of achieving only household ambulation at discharge was 20 (95%CI: 6-63) for Sample 1 and 32 (95%CI: 10-96) for Sample 2 when the combination of having a Berg Balance Scale score ≤ 20 and a FIM walk item score of 1 or 2 was present.

Conclusion: A Berg Balance Scale score of ≤ 20 and a FIM walk item score of 1 or 2 at admission indicates that a person with stroke is highly likely to only achieve household ambulation speeds at discharge from an IRF.

Key Words: stroke, gait, ambulation, inpatient rehabilitation, physical therapy

Abbreviations:

IRF: Inpatient Rehabilitation Facility

FIM: Functional Independence Measure

Introduction

Admission to an inpatient rehabilitation facility (IRF) improves functional outcomes in people post-stroke, with the greatest clinical gains seen in those with mild to moderate deficits.[1] The most common reason for inpatient rehabilitation referral is the inability to walk safely without physical assistance.[2] Independent ambulation is stated as the most frequent goal for persons who have had a stroke.[3] There is a growing body of literature supporting the prognostic value of various clinical assessments in predicting walking ability at six months post-stroke,[4, 5] and 80-90% of stroke patients with acute hemiparesis have been shown to achieve independent ambulation although most still have considerable gait deficits.[6] Walking speed is the most common indicator of walking ability in people post-stroke[7-9]. At discharge from inpatient rehabilitation, early clinical assessment data have been shown to predict walking speed. The time between assessment and prediction in these studies (i.e., length of stay) was relatively long however, averaging 26-60 days.[10-12] In comparison, average lengths of stay post-stroke at IRFs in the United States are currently 16-17 days.[2, 13]

As a result of short lengths of stay, delivery of services must be efficient,[2] and clinicians must make quick and accurate prognostic decisions shortly after admission about the outcome a person with stroke is expected to achieve by discharge. Early prediction of outcomes is important for: 1) setting realistic and attainable therapeutic goals, 2) facilitating proper discharge planning, and 3) anticipating the need for specific durable medical equipment, home modifications and community support.[14] Establishment of a clinical decision rule which can provide an estimate of a clinical outcome (discharge walking ability)[15] may decrease inaccurate predictions (delayed discharges, last minute home renovations, unnecessary durable medical equipment). With the current short lengths of stay, knowledge of how assessment results at admission predict walking ability at discharge would be extremely useful to rehabilitation clinicians. For example, persons whose walking ability is expected to be poor at discharge might be best served by retraining bathing and dressing skills from a sitting position versus a standing position.

The aims of this study, were to: 1) determine which clinical assessments administered at admission to an IRF could most parsimoniously predict discharge walking ability in people who have had a stroke, and 2) construct a clinical decision rule to assist clinicians in differentiating between persons who will be able to ambulate in the household only verses in the community at time of discharge from an IRF. This study capitalizes on an established clinical and research infrastructure, whereby persons admitted to our IRF with the diagnosis of stroke undergo standardized assessment batteries by physical therapy, occupational therapy, and speech-language pathology services at admission and discharge.[16] Specific assessment tools in the physical therapy battery include common measures of impairment (e.g. paresis, tone) and activity (e.g. balance, walking speed). Because clinicians must make prognostic decisions for all persons with stroke, our sample includes both those with first stroke and those with recurrent strokes. Walking ability was quantified by speed on the 10 m Walk Test. This measure is commonly used in both clinical practice and in research studies,[17, 18] it is quick to administer, and does not suffer from ceiling effects like the Functional Independence Measure (FIM).[19] We hypothesized that information from the admission assessment could be used to reasonably predict discharge walking ability.

Methods

Data for this retrospective cohort study were obtained through participant records stored in the Brain Recovery Core database. The Brain Recovery Core is a partnership between Washington University School of Medicine, Barnes Jewish Hospital, and The Rehabilitation Institute of St. Louis. The Brain Recovery Core is a system of organized stroke rehabilitation across the continuum of care, from the acute stroke service to return to home and community life.[16] As part of the system, rehabilitation data are stored from participants across all three institutions. All participants entered into the database have a primary stroke diagnosis and have provided informed consent to have their stroke rehabilitation data stored and used for research. Washington University Human Research Protection Office has approved the database and studies using de-identified data.

Two separate samples were extracted from the database; the first was used to generate the model and clinical decision rule and the second was used to validate them. The first sample was from April 2010 and January 2011 and contained 227 records. The second sample was from February 2011 to February 2012 and contained 288 records. All participants admitted to The Rehabilitation Institute of St. Louis undergo standardized assessments by physical therapy, occupational therapy, and speech-language pathology within 48 hours of admission and discharge as part of the Brain Recovery Core system.[16] All assessments are administered by licensed clinicians who have been trained on these assessments, complete annual competencies on them, and who are observed for consistency. All participants received standard physical therapy of one hour per day, five times per week, similar to other institutions across the United States.[20] Standard physical therapy in our facility most often includes gait (over-ground or with a gait assist machine), balance, transfer, and stair training, and therapeutic exercises.

Variables Assessed

Independent variables from the physical therapy admission assessment included: Motricity Index ,[4, 21] somatosensation of the dorsum of the foot,[22, 23] Modified Ashworth Scale for plantarflexors,[24] FIM walk item,[25-27] the Berg Balance Scale,[28, 29] and 10 m Walk Speed.[8, 17, 18, 25] Where applicable the affected side was used for analysis. For the 10 m Walk, participants were asked to walk at a self-selected pace. They could walk with an assistive device as necessary. Participants who could not walk without physical assistance from another person were assigned a walking speed of 0 m/s.[30, 31] In addition to the above clinical assessments, age and time from stroke onset to assessment at the IRF were also obtained and included as independent variables. The dependent variable, Discharge 10 m Walk Speed, was obtained at the physical therapy discharge assessment.

Statistical Analysis

SPSS version 19 (IBM Corporation; Armonk, New York) was used for all statistical analyses and the criterion for statistical significance was set at $p < 0.05$. Distributions of independent and dependent variables were examined using Kolmogorov-Smirnov tests. We first examined distributions of participants with first strokes versus those with multiple strokes. T-tests were used to determine if differences existed between the groups on all variables. If no statistical difference was found, then all participants were analyzed together.

Starting with the first sample, Pearson Product Moment correlations were used to examine relationships between the independent variables and the dependent variable. All independent variables were entered into a backward, step-wise multiple regression model to determine the most parsimonious combination of variables that could explain variance in the discharge 10 m walk speed. The probability of F for entry was $p = 0.05$ and for removal was $p = 0.10$. Squared semi-partial correlations from the regression model were used to determine the amount of unique variance attributed to each significant independent variable.

A logistic regression model was used to determine the likelihood of achieving household (< 0.4 m/s) versus community (limited community = ≥ 0.4 – 0.8, full community = > 0.8 m/s) ambulation speeds.[8] The dependent variable was dichotomized into household and community ambulation to yield a simple rule by which clinicians can predict the probability of a participant ambulating only at a household level at time of discharge from an IRF. Sensitivity, specificity, positive and negative predictive values and their 95% confidence intervals were generated from the logistic model.[32, 33] Finally, the multiple and logistic regression models were checked for validity by replicating the above analyses on the second sample.

Results

Of the 227 participants screened for Sample 1, 110 were included (Figure 1A); of the 288 participants screened for Sample 2, 159 were included (Figure 1B). Characteristics for each sample are shown in the top of Table 1. The values in Table 1 indicate both samples were reasonably representative of IRF stroke populations in the United States, but with higher percentages of African-Americans. Descriptive statistics for admission variables and discharge walking ability are shown in the bottom of Table 1. At admission, most participants required moderate to maximal assist for mobility, demonstrated poor balance and were unable to walk independently. At discharge, 10 m walk speeds for both samples were more variable, ranging from 0 – 2.2 m/s. T-tests for all independent and dependent variables compared participants who had a first stroke with participants who had multiple strokes, but found no significant differences between the groups (all p values < 0.05); participants with one or multiple strokes were grouped together for all subsequent analyses.

Generating the model and clinical decision rule: Sample 1

Table 2 shows correlations between the independent variables and the dependent variable. Of the eight admission variables, seven were significantly associated with discharge 10 m walk speed. The Berg Balance scale had the highest correlation of 0.72. For the regression analysis, two variables, the Berg Balance Scale ($B = 0.02$, $SE = .003$; $\beta =.55$, $p \leq 0.001$) and the FIM walk item ($B = 0.10$, $SE =0.03$; $\beta = 0.37$, $p = 0.001$) remained in the final model explaining a total of 81% of the variance in discharge walking speed ($R^2 = 0.81$; $p<0.001$). Squared semi-partial correlations indicated that the Berg Balance Scale uniquely explained 7% and the FIM walk item uniquely explained 3% of the total variance. The majority of the variance (71%) in discharge walking speed was accounted for by the combination of the two variables. To better appreciate the relationships between the significant predictor variables and the dependent variable, each participant's data from Sample 1 are displayed in a 3-dimensional graph (Figure 2). In general, participants who have low Berg Balance Scale and FIM walk item scores at admission achieve household ambulation speeds at discharge from an IRF. Those ambulating at a community level at discharge tend to have a wider distribution of admission Berg Balance Scale and/or FIM walk item scores.

The Berg Balance Scale, FIM walk item, and the interaction of the two scores were entered into a logistic regression model to determine if a simple clinical decision rule could be constructed to predict whether someone would achieve household or community ambulation walking speeds at discharge. The independent variables were dichotomized as follows: Berg Balance Scale score of ≤ 20 versus > 20 because this was a published cut-off representing balance impairment,[34] and FIM walk item score of 1 or 2 versus ≥ 3 because scores of 1 or 2 represent total to maximum assistance required for ambulation.[25, 26] The final model indicated that it was the combination of having a Berg Balance Scale score of ≤ 20 and a FIM walk item score of 1 or 2 that determined whether or not a participant would achieve household or community ambulation speeds (B = 2.97, SE = 0.59; OR = 20, 95% CI of OR = 6.2-61.7). The overall model correctly classified 83 of the 110 (76%) participants, with 92% of participants who achieved only household ambulation levels by discharge correctly classified. Of the misclassified participants, 22/27 were classified as household ambulators (false positives) but achieved walking speeds between 0.4 – 0.8 m/s (limited community ambulation) by discharge.

The odds ratio, sensitivity, specificity, positive predictive values, negative predictive values, 95% confidence intervals, and interpretations of these values are provided in Table 3. Post-hoc explorations of the model indicated that small manipulations of the cut-off Berg Balance Scale score (i.e. 18-22) resulted in only slight changes to the B values (2.13-3.73) and odds ratios (18-42).

Validating the model and clinical decision rule: Sample 2

Validity was supported via a second, separate sample of IRF participants. For the multiple regression analysis, the same variables remained in the model (Berg Balance Scale, B = 0.02, SE = .003; β =.52, $p \leq 0.001$; FIM walk item, B = 0.12, SE =0.03; β = 0.38, $p \leq 0.001$) and together explained 77% of the variance seen in discharge walking speed ($R^2 = 0.77$; $p<0.001$). For the logistic regression, the same combination of Berg Balance Scale and FIM walk item was observed (B = 3.45, SE = 0.57; OR = 32, 95% CI of OR = 10.4-96.3). Correct classification occurred in 115 of the 159 (72%) cases, with 94% of participants who achieved only household ambulation levels by discharge correctly classified (see Table 3 for additional values).

Discussion

Results from these IRF samples of people with stroke demonstrate that discharge walking ability can be predicted from admission assessment scores. While there were significant correlations between many of the admission assessment scores and the outcome, two scores, the Berg Balance Scale and the FIM Walk item, predicted the majority of the variance in discharge walking ability. Results from the logistic regression indicate that people with a Berg Balance Scale score of ≤ 20 and a FIM walk score of 1 or 2 at the time of admission to an IRF are highly likely to achieve only household ambulation at the time of discharge.

Our finding that the Berg Balance Scale and FIM walk item scores can predict the majority of variance in discharge walking ability is consistent with current literature which suggests that balance[12, 14, 35-37] and initial walking function[10, 38, 39] are key components in determining eventual walking ability. Previous models predicting walking ability at the time of discharge from an IRF have explained 27.5% - 66% of the variance,[10-12] whereas the current models predicted 81% and 77%, respectively. Using these data, we have determined a clinical decision rule that can be used when treating persons with stroke during the short IRF stays currently experienced in the United States: *if a person has a Berg Balance Scale score of ≤ 20 and a FIM walk item score of 1 or 2 at admission to an IRF, then they are likely to only achieve household ambulation speeds by the time of discharge*. This rule can facilitate discharge planning and assist the rehabilitation team with setting realistic and obtainable therapeutic goals during the planned length of stay.

The model correctly classified 92% and 94% of participants in Samples 1 and 2 who achieved only household ambulation levels by discharge, and overall, correctly classified the majority (76% and 67%, respectively) of participants. The sensitivity and negative predictive value of the model were high (Table 3), while the specificity and positive predictive value were moderate. Previous models predicting walking outcomes during IRF stays have not reported these values, making it hard to compare to our data. Other models predicting the likelihood of independent gait at six months have attained similar predictive values to ours. Across the literature, the significant predictor variables vary somewhat, but generally are indexes of paretic severity,[4, 5] balance,[12] and initial walking ability.[10, 11] Differences in specific predictor variables may arise from a number of sources, such as slightly different lists of potential predictor variables, time post stroke when the predictor variables were collected, time post stroke of the predicted walking ability, and differences in patient populations (IRF patients only versus all persons with stroke admitted at an acute hospital). Driven by clinical needs, we were most interested in identifying who would achieve only household ambulation by the time of IRF discharge. These are the people who will most likely need durable medical equipment, supervision or physical assistance when performing activities of daily living, and/or structural modifications to be safe at home. Given the current short IRF length of stays in the United States for people with stroke,[2, 13] accommodations for a safe discharge need to be in place in approximately two weeks. If clinicians can better prepare families for the amount of assistance a patient will need, patients post-stroke may be more likely to be discharged home safely.

Most of the misclassified participants who were incorrectly identified as household ambulators went on to achieve only limited community ambulation speeds. From a clinical perspective, a decision rule that under-estimates discharge walking ability (over-estimates discharge needs) is safer than a rule that does the reverse. The issue of safety after stroke is of utmost importance, given that 72% of this population fall within the first 6 months post stroke and are twice as likely to sustain a hip fracture from falling.[40-42]

A strength of these results are their potential ability to generalize to other IRF stroke populations. Both samples analyzed here came from a rehabilitation database that stores clinical information on all patients admitted with stroke[16], and not from a sample with strict inclusion/exclusion criteria as is typical with data derived from experimental or clinical trial protocols. Thus, the people in this sample are similar to the people with stroke at many other IRFs in the United States, as indicated by their demographics and admission assessment scores (Table 1).[43] Similarly, the collected data came from assessments completed by physical therapy clinicians, not from research staff, making it more likely that the results will generalize to routine clinical practice. People in the sample received standard rehabilitation services during their length of stay. As new evidence emerges and standard stroke rehabilitation changes, future studies may be needed to re-evaluate the model.

Study Limitations

Three limitations need to be considered when interpreting the results from this study. First, selection of the specific physical therapy assessments was dependent on those already in use at our facility.[16] Other assessment tools, not included in our standardized battery, might have done equally well at predicting discharge walking ability. Second, there was no explicit test of the reliability of the physical therapy assessments performed. Reliability and validity for each of the assessments however, has been previously established (see Methods). All physical therapists at our facility have been trained how to administer each clinical assessment, have to complete annual competencies on these assessments as part of their annual review, and have been observed for consistency. While it is likely that the physical therapists who administered these assessments were not as reliable as raters in a randomized controlled trial may have been, the data collected here are likely to be at least as reliable as data collected during routine clinical care at other IRFs. Third, co-morbidities were not routinely collected on all participants. Because the sample consisted of all patients with stroke admitted to an IRF, we assume that participants have a variety of co-morbidities. We are not able to determine if any particular co-morbidity would have influenced the results.

Conclusions

In summary, our results indicate that a person after a stroke who has the combination of a Berg Balance Scale score ≤ 20 and a FIM walk item score of 1 or 2 on admission to an IRF is highly likely (20-32 times more likely than not) to be only a household ambulator at time of discharge. Knowing at the time of IRF admission that a person with stroke is *not* likely to achieve community ambulation status will assist clinicians in making quick and accurate prognostic decisions and allow for earlier discharge planning. Future studies are needed to extend the time frame of this prediction model beyond discharge from the IRF to long-term community living.

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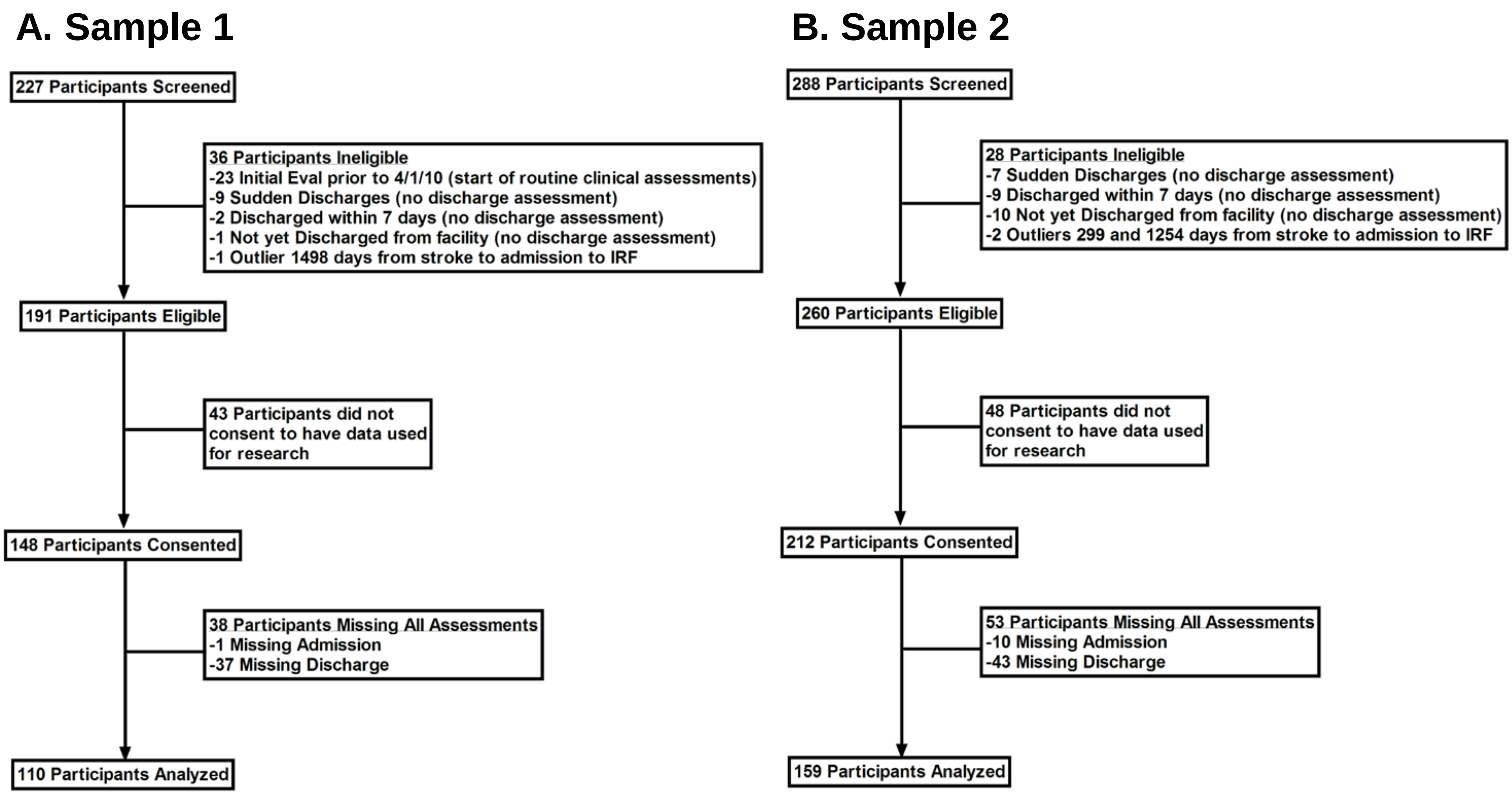
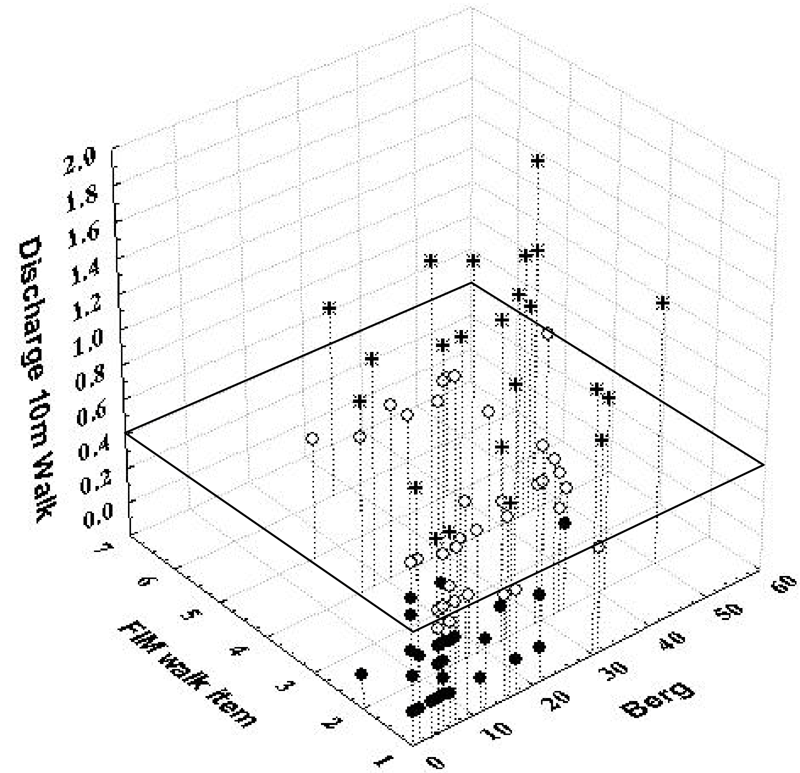

A. Sample 1
227 Participants Screened
36 Participants Ineligible
-23 Initial Eval prior to 4/1/10 (start of routine clinical assessments)
-9 Sudden Discharges (no discharge assessment)
-2 Discharged within 7 days (no discharge assessment)
-1 Not yet Discharged from facility (no discharge assessment)
-1 Outlier 1498 days from stroke to admission to IRF
191 Participants Eligible
43 Participants did not consent to have data used for research
148 Participants Consented
38 Participants Missing All Assessments
-1 Missing Admission
-37 Missing Discharge
110 Participants Analyzed
B. Sample 2
288 Participants Screened
28 Participants Ineligible
-7 Sudden Discharges (no discharge assessment)
-9 Discharged within 7 days (no discharge assessment)
-10 Not yet Discharged from facility (no discharge assessment)
-2 Outliers 299 and 1254 days from stroke to admission to IRF
260 Participants Eligible
48 Participants did not consent to have data used for research
212 Participants Consented
53 Participants Missing All Assessments
-10 Missing Admission
-43 Missing Discharge
159 Participants Analyzed



<u>Walking Speed (m/s)</u>

- < 0.4 Household ambulation
- o 0.4-0.8 Limited community ambulation
- ∗ > 0.8 Community ambulation

Figure Legends

Figure 1. A: Of the 227 participants initially screened for Sample 1, 110 participants consented and had available clinical assessments for analysis. B: Of the 288 participants initially screened for Sample 2, 159 participants consented and had available clinical assessments for analysis.

Figure 2. Three-dimensional representation of the multiple regression model for Sample 1. Each data point is a participant. Data points from participants with the same score across all three measures (e.g. Berg Balance Scale =10, FIM walk item = 1, 10m walk test = 0) are overlaid. The black box represents the cut-off walking speed between household and community ambulation classifications.

Table 1. Sample characteristics, description statistics for admission and discharge variables.

	Sample 1 Mean (SD)	Range or %	**Sample 2** Mean (SD)	Range or %
Age at stroke (yr)	62 (14)	26-89	63 (15)	21-93
Gender				
Women	59	54%	75	47%
Men	51	46%	84	53%
Race				
African Americans	64	58%	103	65%
Caucasian	44	40%	53	33%
Asian	1	1%	1	1%
Other	1	1%	2	1%
First stroke	73	66%	109	69%
Type of stroke				
ischemic	74	67%	107	67%
hemorrhagic	18	16%	19	12%
unknown/missing	18	16%	33	21%
Affected Side				
left	52	47%	54	34%
right	37	34%	70	44%
bilateral	7	6%	9	6%
unknown/missing	14	13%	26	16%
Stroke-IRF Assessment (days)*	5 (4)	2-60	4 (5)	1-91
Length of Stay (days)*	14 (10)	3-74	17 (14)	3-63

Admission	**Sample 1** Mean (SD)	Range or %	**Sample 2** Mean (SD)	Range or %
Lower Extremity Motricity Index†	65 (26)	0-100	59 (30)	0-100
Somatosensation†				
intact	63	57%	95	60%
impaired	24	22%	24	15%
absent	9	8%	7	4%
not tested	7	6%	29	18%
missing	7	6%	4	3%
Modified Ashworth Scale†				
0	64	58%	118	74%
1	12	11%	18	11%
1+	2	2%	7	4%
2	3	3%	5	3%
3	2	2%	3	2%
4	0	0%	0	0%
not tested	2	2%	4	3%
missing	25	23%	4	3%
FIM walk item*	1 (1)	1-6	1 (2)	1-5
Berg Balance Scale	16 (14)	0-50	16 (15)	0-50
10 m Walk Speed*	0 (0)	0-1.2	0 (0)	0-1.4

Discharge	**Sample 1** Mean (SD)	Range or %	**Sample 2** Mean (SD)	Range or %
10 m Walk Speed*	0.5 (0.8)	0-1.8	0.4 (0.9)	0-2.2

T-tests indicated that the samples were not statistically different from each other (all p values > 0.05)

*Median, Interquartile Range

†Affected or more involved side