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

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2

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28

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41 **Abstract**

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

45 **Design:** Retrospective cohort study

46 **Setting:** Inpatient Rehabilitation Facility (IRF)

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

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

55 **Main Outcome Measure:** Discharge 10 m Walk Speed

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

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

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

65 **Abbreviations:**

66 IRF: Inpatient Rehabilitation Facility

67 FIM: Functional Independence Measure

68 **Introduction**

69 Admission to an inpatient rehabilitation facility (IRF) improves functional outcomes in
70 people post-stroke, with the greatest clinical gains seen in those with mild to moderate
71 deficits.¹ The most common reason for inpatient rehabilitation referral is the inability to walk
72 safely without physical assistance.² Independent ambulation is stated as the most frequent goal
73 for persons who have had a stroke.³ There is a growing body of literature supporting the
74 prognostic value of various clinical assessments in predicting walking ability at six months post-
75 stroke,^{4,5} and 80-90% of stroke patients with acute hemiparesis have been shown to achieve
76 independent ambulation although most still have considerable gait deficits.⁶ Walking speed is
77 the most common indicator of walking ability in people post-stroke⁷⁻⁹. At discharge from
78 inpatient rehabilitation, early clinical assessment data have been shown to predict walking
79 speed. The time between assessment and prediction in these studies (i.e., length of stay) was
80 relatively long however, averaging 26-60 days.¹⁰⁻¹² In comparison, average lengths of stay post-
81 stroke at IRFs in the United States are currently 16-17 days.^{2,13}

82 As a result of short lengths of stay, delivery of services must be efficient,² and clinicians
83 must make quick and accurate prognostic decisions shortly after admission about the outcome
84 a person with stroke is expected to achieve by discharge. Early prediction of outcomes is
85 important for: 1) setting realistic and attainable therapeutic goals, 2) facilitating proper
86 discharge planning, and 3) anticipating the need for specific durable medical equipment, home
87 modifications and community support.¹⁴ Establishment of a clinical decision rule which can
88 provide an estimate of a clinical outcome (discharge walking ability)¹⁵ may decrease inaccurate
89 predictions (delayed discharges, last minute home renovations, unnecessary durable medical

90 equipment). With the current short lengths of stay, knowledge of how assessment results at
91 admission predict walking ability at discharge would be extremely useful to rehabilitation
92 clinicians. For example, persons whose walking ability is expected to be poor at discharge
93 might be best served by retraining bathing and dressing skills from a sitting position versus a
94 standing position.

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

111

112 **Methods**

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

123 Two separate samples were extracted from the database; the first was used to generate
124 the model and clinical decision rule and the second was used to validate them. The first sample
125 was from April 2010 and January 2011 and contained 227 records. The second sample was
126 from February 2011 to February 2012 and contained 288 records. All participants admitted to
127 The Rehabilitation Institute of St. Louis undergo standardized assessments by physical therapy,
128 occupational therapy, and speech-language pathology within 48 hours of admission and
129 discharge as part of the Brain Recovery Core system.¹⁶ All assessments are administered by
130 licensed clinicians who have been trained on these assessments, complete annual
131 competencies on them, and who are observed for consistency. All participants received
132 standard physical therapy of one hour per day, five times per week, similar to other institutions

133 across the United States.²⁰ Standard physical therapy in our facility most often includes gait
134 (over-ground or with a gait assist machine), balance, transfer, and stair training, and
135 therapeutic exercises.

136

137 *Variables Assessed*

138 Independent variables from the physical therapy admission assessment included:
139 Motricity Index,^{4, 21} somatosensation of the dorsum of the foot,^{22, 23} Modified Ashworth Scale
140 for plantarflexors,²⁴ FIM walk item,²⁵⁻²⁷ the Berg Balance Scale,^{28, 29} and 10 m Walk Speed.^{8, 17,}
141 ^{18, 25} Where applicable the affected side was used for analysis. For the 10 m Walk, participants
142 were asked to walk at a self-selected pace. They could walk with an assistive device as
143 necessary. Participants who could not walk without physical assistance from another person
144 were assigned a walking speed of 0 m/s.^{30, 31} In addition to the above clinical assessments, age
145 and time from stroke onset to assessment at the IRF were also obtained and included as
146 independent variables. The dependent variable, Discharge 10 m Walk Speed, was obtained at
147 the physical therapy discharge assessment.

148

149 *Statistical Analysis*

150 SPSS version 19 (IBM Corporation; Armonk, New York) was used for all statistical
151 analyses and the criterion for statistical significance was set at $p < 0.05$. Distributions of
152 independent and dependent variables were examined using Kolmogorov-Smirnov tests. We

153 first examined distributions of participants with first strokes versus those with multiple strokes.
154 T-tests were used to determine if differences existed between the groups on all variables. If no
155 statistical difference was found, then all participants were analyzed together.

156 Starting with the first sample, Pearson Product Moment correlations were used to
157 examine relationships between the independent variables and the dependent variable. All
158 independent variables were entered into a backward, step-wise multiple regression model to
159 determine the most parsimonious combination of variables that could explain variance in the
160 discharge 10 m walk speed. The probability of F for entry was $p = 0.05$ and for removal was $p =$
161 0.10 . Squared semi-partial correlations from the regression model were used to determine the
162 amount of unique variance attributed to each significant independent variable.

163 A logistic regression model was used to determine the likelihood of achieving household
164 (< 0.4 m/s) versus community (limited community = $\geq 0.4 - 0.8$, full community = > 0.8 m/s)
165 ambulation speeds.⁸ The dependent variable was dichotomized into household and community
166 ambulation to yield a simple rule by which clinicians can predict the probability of a participant
167 ambulating only at a household level at time of discharge from an IRF. Sensitivity, specificity,
168 positive and negative predictive values and their 95% confidence intervals were generated from
169 the logistic model.^{32, 33} Finally, the multiple and logistic regression models were checked for
170 validity by replicating the above analyses on the second sample.

171

172 **Results**

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

185

186 *Generating the model and clinical decision rule: Sample 1*

187 Table 2 shows correlations between the independent variables and the dependent
188 variable. Of the eight admission variables, seven were significantly associated with discharge 10
189 m walk speed. The Berg Balance scale had the highest correlation of 0.72. For the regression
190 analysis, two variables, the Berg Balance Scale (B = 0.02, SE = .003; β = .55, $p \leq 0.001$) and the
191 FIM walk item (B = 0.10, SE = 0.03; β = 0.37, $p = 0.001$) remained in the final model explaining a
192 total of 81% of the variance in discharge walking speed ($R^2 = 0.81$; $p < 0.001$). Squared semi-
193 partial correlations indicated that the Berg Balance Scale uniquely explained 7% and the FIM

194 walk item uniquely explained 3% of the total variance. The majority of the variance (71%) in
195 discharge walking speed was accounted for by the combination of the two variables. To better
196 appreciate the relationships between the significant predictor variables and the dependent
197 variable, each participant's data from Sample 1 are displayed in a 3-dimensional graph (Figure
198 2). In general, participants who have low Berg Balance Scale and FIM walk item scores at
199 admission achieve household ambulation speeds at discharge from an IRF. Those ambulating at
200 a community level at discharge tend to have a wider distribution of admission Berg Balance
201 Scale and/or FIM walk item scores.

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

216 The odds ratio, sensitivity, specificity, positive predictive values, negative predictive values, 95%
217 confidence intervals, and interpretations of these values are provided in Table 3. Post-hoc
218 explorations of the model indicated that small manipulations of the cut-off Berg Balance Scale
219 score (i.e. 18-22) resulted in only slight changes to the B values (2.13-3.73) and odds ratios (18-
220 42).

221

222 *Validating the model and clinical decision rule: Sample 2*

223 Validity was supported via a second, separate sample of IRF participants. For the
224 multiple regression analysis, the same variables remained in the model (Berg Balance Scale, $B =$
225 0.02 , $SE = .003$; $\beta = .52$, $p \leq 0.001$; FIM walk item, $B = 0.12$, $SE = 0.03$; $\beta = 0.38$, $p \leq 0.001$) and
226 together explained 77% of the variance seen in discharge walking speed ($R^2 = 0.77$; $p < 0.001$).
227 For the logistic regression, the same combination of Berg Balance Scale and FIM walk item was
228 observed ($B = 3.45$, $SE = 0.57$; $OR = 32$, 95% CI of $OR = 10.4-96.3$). Correct classification
229 occurred in 115 of the 159 (72%) cases, with 94% of participants who achieved only household
230 ambulation levels by discharge correctly classified (see Table 3 for additional values).

231

232 **Discussion**

233 Results from these IRF samples of people with stroke demonstrate that discharge
234 walking ability can be predicted from admission assessment scores. While there were
235 significant correlations between many of the admission assessment scores and the outcome,

236 two scores, the Berg Balance Scale and the FIM Walk item, predicted the majority of the
237 variance in discharge walking ability. Results from the logistic regression indicate that people
238 with a Berg Balance Scale score of ≤ 20 and a FIM walk score of 1 or 2 at the time of admission
239 to an IRF are highly likely to achieve only household ambulation at the time of discharge.

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

252 The model correctly classified 92% and 94% of participants in Samples 1 and 2 who
253 achieved only household ambulation levels by discharge, and overall, correctly classified the
254 majority (76% and 67%, respectively) of participants. The sensitivity and negative predictive
255 value of the model were high (Table 3), while the specificity and positive predictive value were
256 moderate. Previous models predicting walking outcomes during IRF stays have not reported

257 these values, making it hard to compare to our data. Other models predicting the likelihood of
258 independent gait at six months have attained similar predictive values to ours. Across the
259 literature, the significant predictor variables vary somewhat, but generally are indexes of
260 paretic severity,^{4, 5} balance,¹² and initial walking ability.^{10, 11} Differences in specific predictor
261 variables may arise from a number of sources, such as slightly different lists of potential
262 predictor variables, time post stroke when the predictor variables were collected, time post
263 stroke of the predicted walking ability, and differences in patient populations (IRF patients only
264 versus all persons with stroke admitted at an acute hospital). Driven by clinical needs, we were
265 most interested in identifying who would achieve only household ambulation by the time of IRF
266 discharge. These are the people who will most likely need durable medical equipment,
267 supervision or physical assistance when performing activities of daily living, and/or structural
268 modifications to be safe at home. Given the current short IRF length of stays in the United
269 States for people with stroke,^{2, 13} accommodations for a safe discharge need to be in place in
270 approximately two weeks. If clinicians can better prepare families for the amount of assistance
271 a patient will need, patients post-stroke may be more likely to be discharged home safely.
272 Most of the misclassified participants who were incorrectly identified as household ambulators
273 went on to achieve only limited community ambulation speeds. From a clinical perspective, a
274 decision rule that under-estimates discharge walking ability (over-estimates discharge needs) is
275 safer than a rule that does the reverse. The issue of safety after stroke is of utmost importance,
276 given that 72% of this population fall within the first 6 months post stroke and are twice as
277 likely to sustain a hip fracture from falling.⁴⁰⁻⁴²

278 A strength of these results are their potential ability to generalize to other IRF stroke
279 populations. Both samples analyzed here came from a rehabilitation database that stores
280 clinical information on all patients admitted with stroke¹⁶, and not from a sample with strict
281 inclusion/exclusion criteria as is typical with data derived from experimental or clinical trial
282 protocols. Thus, the people in this sample are similar to the people with stroke at many other
283 IRFs in the United States, as indicated by their demographics and admission assessment scores
284 (Table 1).⁴³ Similarly, the collected data came from assessments completed by physical therapy
285 clinicians, not from research staff, making it more likely that the results will generalize to
286 routine clinical practice. People in the sample received standard rehabilitation services during
287 their length of stay. As new evidence emerges and standard stroke rehabilitation changes,
288 future studies may be needed to re-evaluate the model.

289

290 *Study Limitations*

291 Three limitations need to be considered when interpreting the results from this study.
292 First, selection of the specific physical therapy assessments was dependent on those already in
293 use at our facility.¹⁶ Other assessment tools, not included in our standardized battery, might
294 have done equally well at predicting discharge walking ability. Second, there was no explicit
295 test of the reliability of the physical therapy assessments performed. Reliability and validity for
296 each of the assessments however, has been previously established (see Methods). All physical
297 therapists at our facility have been trained how to administer each clinical assessment, have to
298 complete annual competencies on these assessments as part of their annual review, and have

299 been observed for consistency. While it is likely that the physical therapists who administered
300 these assessments were not as reliable as raters in a randomized controlled trial may have
301 been, the data collected here are likely to be at least as reliable as data collected during routine
302 clinical care at other IRFs. Third, co-morbidities were not routinely collected on all participants.
303 Because the sample consisted of all patients with stroke admitted to an IRF, we assume that
304 participants have a variety of co-morbidities. We are not able to determine if any particular co-
305 morbidity would have influenced the results.

306

307 *Conclusions*

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

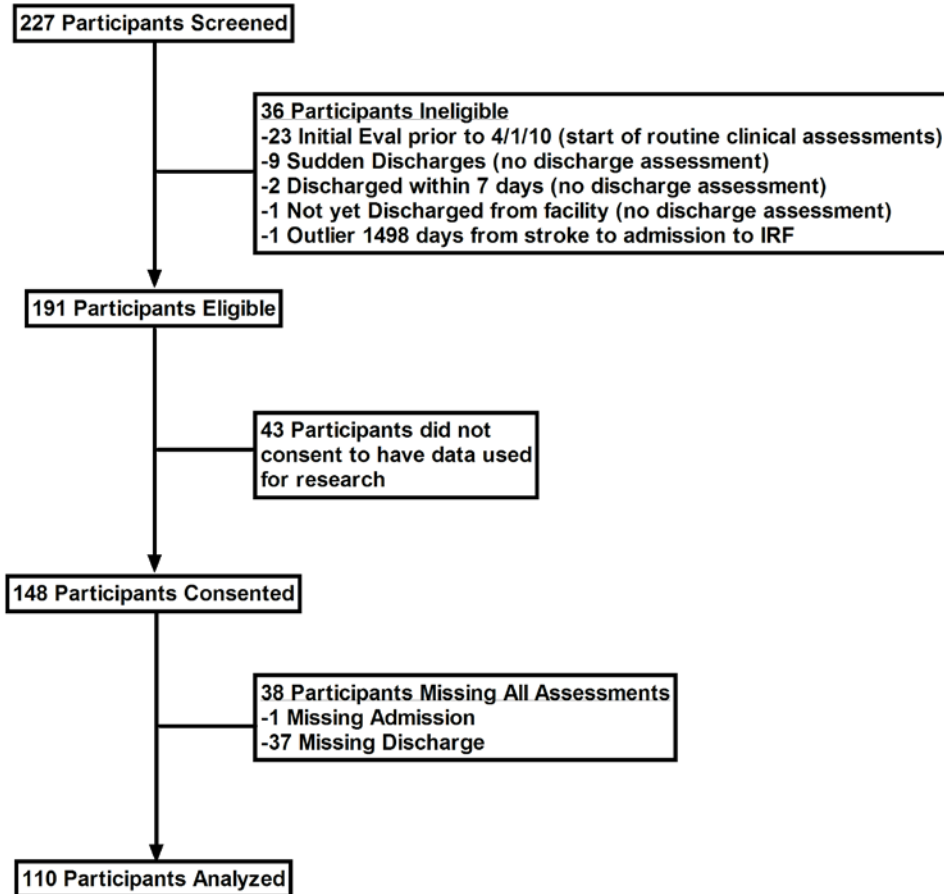
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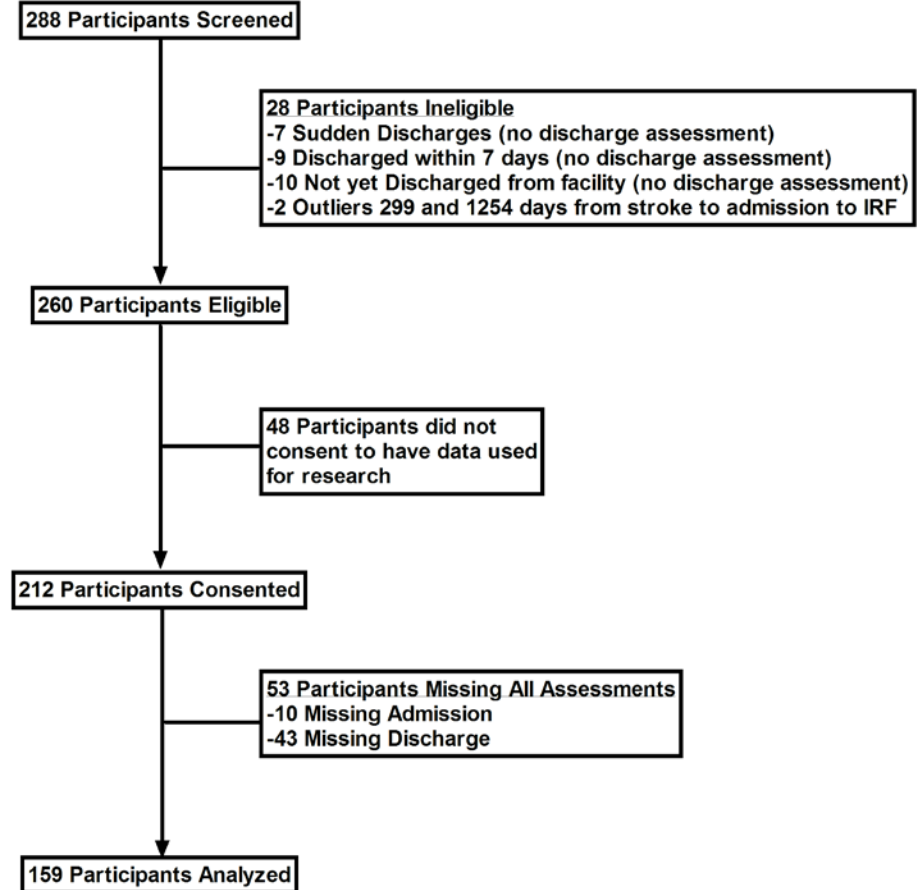
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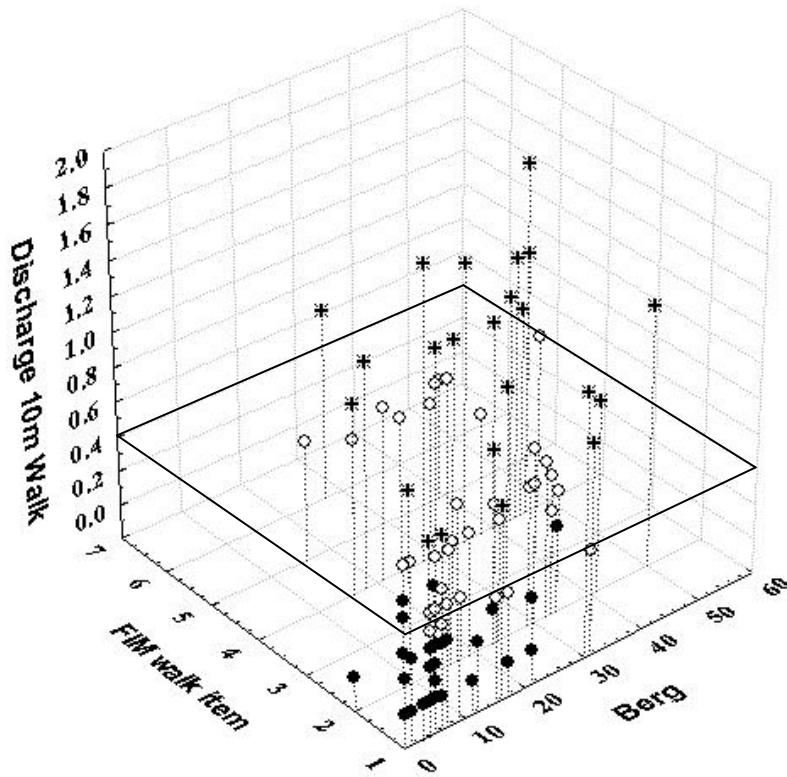
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A. Sample 1



B. Sample 2





Walking Speed (m/s)

- < 0.4 Household ambulation
- 0.4-0.8 Limited community ambulation
- * > 0.8 Community ambulation

410 **Figure Legends**

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

414 **Figure 2.** Three-dimensional representation of the multiple regression model for Sample 1. Each data
415 point is a participant. Data points from participants with the same score across all three measures (e.g.
416 Berg Balance Scale =10, FIM walk item = 1, 10m walk test = 0) are overlaid. The black box represents the
417 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
<hr/>				
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
<hr/>				
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