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Using Functional Independence Measure Subscales to Predict Falls—Rapid Assessment

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Background: Falls remain a major issue in inpatient rehabilitation. Decreased scores on the Functional Independence Measure (FIM), given to every patient, have been shown to predict falls risk.
Purpose: The aim of the study was to extend previous research using FIM to predict falls by using only subscales assessed earliest during admissions to indicate high risk of falls.
Design: Retrospective cohort study.
Methods: Two consecutive samples of patients (n_1 = 1,553, n_2 = 12,301) admitted to a rehabilitation hospital over 9-month and 5-year periods, respectively, were used to evaluate the predictive utility of using only a small number of FIM subscales. Subscales were selected from those assessed earliest and were related to previously published research on falls risk factors. The metric was developed using a historical data set and was validated with a second, separate group of patients. Receiver operating characteristic curves were used to evaluate predictive utility.
Findings: The combination of Toileting and Expression subscales yielded a comparable area under the curve to the full FIM, and both were greater than the existing method of falls risk assessment. Likelihood of falling was strongly linearly related to score on the Toileting/Expression metric.
Conclusions: The sum of two FIM subscales can be used to predict which patients may fall during their stay in a rehabilitation hospital.
Clinical Relevance: The FIM scores are assessed early during a patient's stay, are required for all Medicare patients, and may be useful for simple, rapid, and accurate assignment of falls risk.

Keywords: Accidental falls; brain injuries; inpatients; rehabilitation; stroke.

Falls represent a major risk to inpatient rehabilitation facilities/units (IRF/Units), both from a patient health standpoint and from a financial perspective. An unintended fall can have a range of unwanted consequences, and even in cases where there is no injury, staff resources are allocated to evaluate the patient and document the incident. At the other extreme are cases resulting in serious injury or death. Such cases represent serious financial liabilities to the hospital, including drains on staff time and resources and possible lawsuits resulting from the accident (Lee & Stokic, 2008; Saverino, Benevolo, Ottonello, Zsirai, & Sessarego, 2006; Suzuki et al., 2005). In addition, falls sustained while admitted to inpatient rehabilitation are associated with longer lengths of stay (Wong, Brooks, & Mansfield, 2016) and negative psychological effects (Batchelor, Mackintosh, Said, & Hill, 2012). Recent revisions to the Inpatient Rehabilitation Facility–Patient Assessment Instrument (IRF-PAI) now require that these adverse events are reported to the Centers for Medicare & Medicaid Services (CMS) as of October 1, 2016 (CMS, 2015). Given that an estimated 12.5% of rehabilitation patients fall, cumulatively these events form a serious and expensive burden for hospitals (Vlahov, Meyers, & Al-Ibrahim, 1990).

Particularly within the context of rehabilitation, patients are at increased risk for falling for several specific reasons. It is the nature of rehabilitation to encourage patients to independently regain previous skills (e.g., walking, toileting, dressing), and in doing so, clinical staff must carefully tread the line between maintaining patient safety and encouraging patients to expand functional capabilities. Furthermore, diagnostic groups more heavily represented in IRF/Units, namely stroke and brain injury, are at particular risk of falling due to neurological factors

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such as confusion, agitation, impulsivity, and unilateral spatial neglect (Breisinger, Skidmore, Niyonkuru, Terhorst, & Campbell, 2014; Chen, Hreha, Kong, & Barrett, 2015; Rosario, Kaplan, Khonsari, & Patterson, 2014; Weerdesteyn, de Niet, Van Duijnhoven, Cho, & Geurts, 2008).

Given the serious nature of these events, rehabilitation hospitals have created a number of policies and potential solutions to address the issue of patient falls, with varying success. Practices can be broken down into two categories—assessment of risk and safety practices. The latter includes bed alarms, chair alarms, lap belts, tray tables, one-to-one sitters, and in-room video monitoring systems. In the absence of a uniform identification method, selection of patients to receive these interventions depends on each hospital's respective system of assessment. In their review of fall screening tools, Haines, Hill, Walsh, and Osborne (2007) describe the typical methodology used in the development of these instruments. Risk factors are selected on the basis of logistic or multiple regressions, and point values are assigned based on either the presence or predictive value of the factors, with total scores indicating overall risk of falling. Virtually all falls risk assessment tools are derived via this methodology (see the Agency for Healthcare Research and Quality falls toolkit for multiple examples; Ganz et al., 2013). Given the heterogeneity of treatment and patient case mix across the continuum of care, a great many falls risk assessment instruments exist, each incorporating its own proprietary blend of risk factors and point values. The Joint Commission mandates falls risk assessment in all facilities with implementation left to the individual hospital's discretion. Among the most widely used tools are the Morse Falls Scale (MFS; Morse, 1997), the Hendrich II Falls Risk Model (Hendrich, Bender, & Nyhuis, 2003), the DOWNTON (Downton, 1993), and the STRATIFY (Oliver, Britton, Seed, Martin, & Hopper, 1997).

The MFS is commonly reported as being used in IRF/Units, and scoring is based on a patient's history of falling, comorbidities, the presence of ambulatory aids, the presence of an IV/Heparin lock, gait, and mental status (Forrest, Chen, Huss, & Giesler, 2013). However, many of the falls risk assessments were originally developed in acute care settings and may be less appropriate for use in IRF/Units (Zdobysz, Boradia, Ennis, & Miller, 2005). Numerous studies demonstrate the failure of the MFS in discriminating between fallers and nonfallers in rehabilitation settings (Forrest et al., 2013; Kwan, Kaplan, Hudson-McKinney, Redman-Bentley, & Rosario, 2012; Rosario et al., 2014). As a result, many hospitals have created their own instruments based on their particular case mix, for instance, the Casa Colina Falls Risk Assessment Scale (Rosario et al., 2014) and the Stroke Assessment of Falls Risk (Breisinger et al., 2014). A small number of factors appear repeatedly on these falls risk assessment instruments, namely medications, history of falls, and specific functional abilities including ambulation, toileting, and cognitive abilities (Oliver, Daly, Martin, & McMurdo, 2004). Functional abilities related to toileting and alterations in elimination routinely appear as indications of risk, as does the presence of confusion, agitation, or cognitive deficits (Downton, 1993; Ganz et al., 2013; Hendrich et al., 2003; Morse, 1997; Oliver et al., 1997; Poe, Cvach, Gartrell, Radzik, & Joy, 2005; Rosario et al., 2014).

In IRF/Units, functional abilities are measured by the Functional Independence Measure (FIM), on which poorer scores have been repeatedly associated with risk of falling (e.g., Forrest et al., 2013; Kwan et al., 2012 Rosario et al., 2014). The FIM is an 18-item measure of basic functional capacities across multiple domains based on the extent to which patients require assistance or compensatory strategies. It includes eating, grooming, bathing, dressing (upper body and lower body), toileting, control of bowels and bladder, bed/toilet/tub transfer, ambulation, stair climbing, and five cognitive domains (comprehension, expression, social interaction, problem solving, and memory). The instrument has been shown to be valid, reliable, and sensitive to change when assessing patient disability (Cournan, 2011). Since the introduction of the prospective payment system, IRF/Units are required to score patients on the FIM at admission and discharge (CMS, 2001). Given the widespread use of the FIM, as well as research suggesting a relationship between specific FIM items such as toileting or ambulation and risk of falling, the inclusion of individual FIM into falls risk assessment tools (e.g., Casa Colina Falls Risk Assessment Scale) is not surprising.

Previous research has demonstrated that total FIM score at admission is a valid predictor of falls (Gilewski, Roberts, Hirata, & Riggs, 2007; Forrest et al., 2013; Saverino et al., 2006; Zdobysz et al., 2005). Although, ideally, falls risk can be assessed quickly at the time of admission, the FIM frequently requires several days to completely administer, necessitating classification of all patients as high risk until their functional capacities can be fully assessed by therapists and nurses. A patient may not attempt to climb stairs, for instance, until several days into her or his stay, delaying completion of risk assessment. In some cases, the practice of labeling all patients as high risk until completion of falls risk assessment represents an unnecessary expenditure in resources, and a more rapid approach could potentially prevent some low-risk patients from being mislabeled.

It remains unclear how to best incorporate the speed of common assessment tools, such as the MFS with the predictive utility of the FIM. To date, few studies have attempted to use solely a small number of FIM items to

predict falls. Gilewski and colleagues (2007) found that fallers can be differentiated from nonfallers using only the Mobility and Problem-solving subscales. However, even the Ambulation subscale score may not be assessed on the day of admission, as it requires a patient to attempt to walk 150 feet under the supervision of a therapist. The Casa Colina Scale also uses the Stairs subscale as a factor, which may not be assessed until several days into a patient's stay. More recently, Forrest and Chen (2016) explored the possibility of assessing falls risk based on only a small portion of the full FIM instrument. The researchers found that decreases in single-item FIM scores (walking and problem solving) were associated with increased risk of falling, indicating the validity of this time-sensitive approach.

The purpose of the present study was to evaluate whether the combination of two FIM subscales, specifically the subscales assessed within hours of a patient's admission, can be used to quickly and reliably distinguish between patients who fall and those who do not and to internally validate these findings with a larger sample. Among those FIM items assessed earliest, the Toileting and Expression subscales were selected based on their similarity to items commonly appearing on falls risk assessments. All study protocols were reviewed and approved by the hospital internal review board.

Methods

Participants and Source of Data

The present study took place at a 115-bed rehabilitation hospital. All FIM subscales are scored for patients at the hospital at both admission and time of discharge. Demographic information is also collected and recorded at admission by registered nurses. Scores on the MFS are updated daily, and falls precautions are implemented for patients scoring above 40 points on the scale. The original retrospective data for the present study were sourced from individual patient IRF-PAI results, downloaded through the eRehab database for the months in which patient MFS scores were catalogued in the system, for a total time period of 9 months dating from October 2013 through June 2014. Patient information was linked with falls data downloaded through the Quantros incident reporting database and matched with the IRF-PAI results using unique hospital identification numbers. One hundred percent of fallers were successfully matched. The second data set used to validate the original findings included data from September 2008 through September 2013 and used an identical procedure to match fall incident reports to IRF-PAI results. All adult inpatients admitted during these time periods were eligible for inclusion in the study. Pediatric inpatients were excluded, as the FIM is not normed for children.

Procedure

Of the subscales assessed earliest in a patient's stay (Toilet Hygiene, Transfers, Cognitive Items), the Toileting and Expression subscales were selected based on their similarity to items commonly appearing on falls risk assessments. The two subscales were summed to provide a single, two-item score.

Measures

Dependent Variable

Falls were included without differentiation between commonly defined fall types (anticipated physiological, unanticipated physiological, accidental). Near misses (patients who were caught and lowered to the floor by staff) were excluded.

Independent Variables

The independent variables are as follows: total FIM score, Toileting FIM subscale score, Expression FIM subscale score, sum of Toileting and Expression FIM subscales, MFS score, diagnostic category at admission, and patient age at admission.

Analysis

Independent-sample *t* tests were used to compare patient characteristics between fallers and nonfallers. To compare the predictive utility of the MFS, total FIM score, and scores on small groups of subscales, receiver operating characteristic (ROC) curves were used to calculate sensitivity, specificity, and area under the curve. As higher scores on the MFS indicate higher risk and lower scores on the FIM indicate higher risk, the inverse of each MFS score was used in order to compare the two on the same ROC curve. Sensitivity and specificity are reported for the cutoff value that resulted in the greatest values for each simultaneously. Respective sensitivities and specificities are reported for the total sample, patients grouped by broad diagnostic categories (brain injury, stroke, orthopedic, and cardiac/pulmonary/debility).

Data were analyzed retrospectively, and certain patients received high-risk precautions, representing a confound for predicting fallers versus nonfallers. For this reason, ROC curves are also reported for analyzing high-risk and low-risk patients separately. In order to validate the findings based on the original sample, the metric was retested using a larger sample spanning from September 2008 to September 2013, also downloaded from the eRehab data system. Area under the curve, sensitivities, and specificities

are reported for these samples as well. Pearson's *r* was used to demonstrate the linear relationship between scores on the two-item FIM metric and the likelihood of falling.

Data were tested for normality, and assumptions were met. An alpha level of .05 was used for determining significance throughout the analyses found in the present study, and corresponding 95% confidence intervals are reported where appropriate. All analyses were two-tailed.

Results

Total FIM at Admission, Two-Item Metric, MFS Performance

There were 92 fallers among the total sample of 1,553 patients from October 2013 to June 2014. Fallers, on average, scored more than 22 points lower on their total FIM scores upon admission, as well as scoring significantly lower on both the Toileting and Expression FIM subscales (see Table 1). The curve for total FIM at admission (Figure 1, blue line) and Toileting/Expression sum (yellow) are nearly identical. The two methods yielded similar areas under the curve of .781 and .782, respectively. The ROC curve for the MFS is shown in green. The false positive rate is nearly equal to the true positive rate for nearly every possible score on the instrument. The areas under the curve for both the total FIM at admission and two-item metric curves differed significantly from .5, whereas the area under the curve for the MFS did not (see Table 2).

Two-Item Metric for High-Risk and Low-Risk Patients on MFS

When controlling for previously assigned MFS risk level and associated precautionary actions during a patient's stay, the two-item metric still differentiated between fallers and nonfallers (see Table 3; Figures 2 and 3).

Two-Item Metric for Diagnostic Groups

The two-item metric retained its predictive utility across major diagnostic categories in the hospital. Sensitivity and specificity were greatest for patients with brain injuries (see Table 4), whereas the measure performed the worst for patients in the medical/general rehabilitation category (cardiac, pulmonary, pain or circulatory disorders, neoplasm, or debility; Figures 4, 5, 6, and 7).

Table 1 Patient characteristics, fallers versus nonfallers

	Fallers		Nonfallers			
	M	*SD*	*M*	*SD*	*t* Test	*p*
Total FIM score at admission	42.49	21.48	65.15	19.12	9.87	<.001
Toileting FIM at admission	1.4	1.2	2.78	1.64	10.38	<.001
Expression FIM at admission	3.42	2.19	5.38	1.73	8.39	<.001

Note. FIM = Functional Independence Measure.

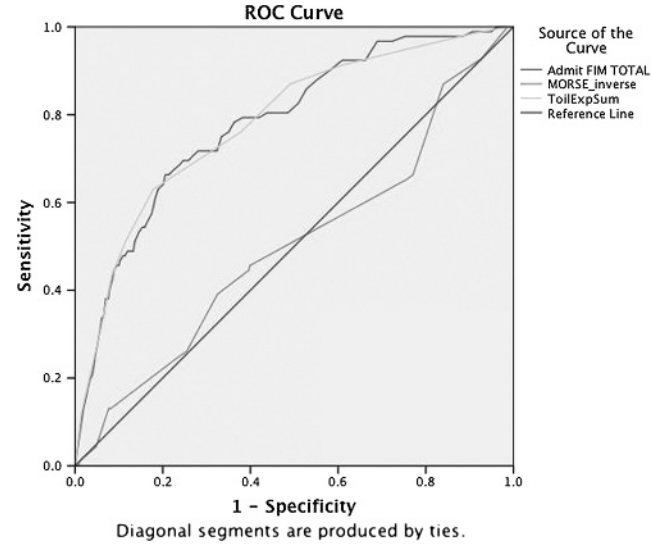

Figure 1. Receiver operating characteristic curve for Morse Falls Scale, total Functional Independence Measure, and two-item metric. Plot of respective sensitivities and specificities for each possible cutoff value for Morse Falls Scale (green), total Functional Independence Measure at admission (blue), and two-item Toileting/Expression metric (yellow).

Two-Item Metric, Internal Validation

In order to validate the two-item metric, the hypothesis was tested on a larger historical patient data set over 5 years (n = 12,301). Of these patients, 804 had at least one fall. The two-item metric yielded an ROC curve with an area under the curve of .754 (95% CI [0.737, 0.772]) for a sensitivity of .669 and a specificity of .729, values similar to those found in the original data set. The proportion of patients who fell in the original data set (5.9%) was similar to the proportion found in the larger data set (6.5%).

Finally, there was a strong negative linear relationship between scores on the two-item metric and probability of falling, $r = -.877$ (see Table 5; Figures 8 and 9).

Discussion

Previous research has suggested that total FIM admission scores, as well as a subset of individual items, may be

Table 2 Receiver operating characteristic curves for whole sample, different methods

Source	Area Under Curve	*n*	95% CI	Sensitivity	Specificity
Total FIM at admission	.781[a]	1,553	[0.733, 0.830]	.717	.719
Two-item FIM metric	.782[a]	1,553	[0.732, 0.832]	.685	.738
MFS	.502	1,553	[0.437, 0.567]	.391	.675

Note. FIM = Functional Independence Measure; MFS = Morse Falls Scale.
[a]Differed significantly from area under curve of .5, $p < .01$.

Table 3 Receiver operating characteristic curves for high-risk and low-risk patients on Morse Falls Scale

Source	Area Under Curve	*n*	95% CI	Sensitivity	Specificity
High risk	.732	625	[0.647, 0.816]	.667	.707
Low risk	.814	928	[0.753, 0.875]	.820	.669

effective in differentiating between fallers and nonfallers in an inpatient rehabilitation context, despite the fact that the FIM was not originally developed as a predictive instrument. Nevertheless, the underlying behaviors and functional abilities measured by the FIM mirror factors such as cognition and toileting that appear frequently on falls risk assessments. Many studies have corroborated this finding, suggesting that the functional capacities captured by the FIM have an important bearing on an individual's likelihood of falling. The current findings provide support to both approaches: Both FIM total score and a two-item composite (Expression, Toileting) predicted falls more accurately than the most commonly utilized fall screening instrument (MFS). The efficacy of the two-item version is particularly noteworthy; unlike the full FIM, these items can typically be completed relatively quickly at the time of admission, allowing nursing staff to implement preventive measures for those deemed high risk while minimizing utilization of limited resources on patients at low risk.

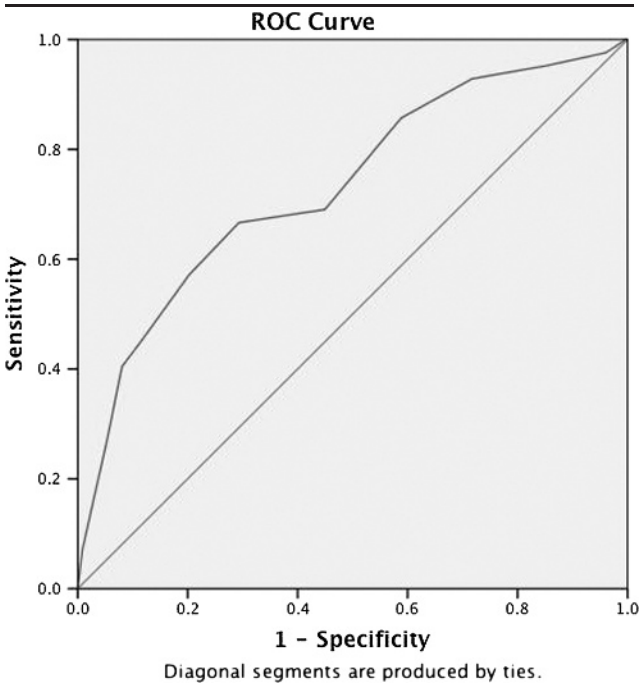

Figure 2. Receiver operating characteristic curve for two-item metric (Morse Falls Scale high-risk patients). Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients labeled high falls risk on Morse Falls Scale.

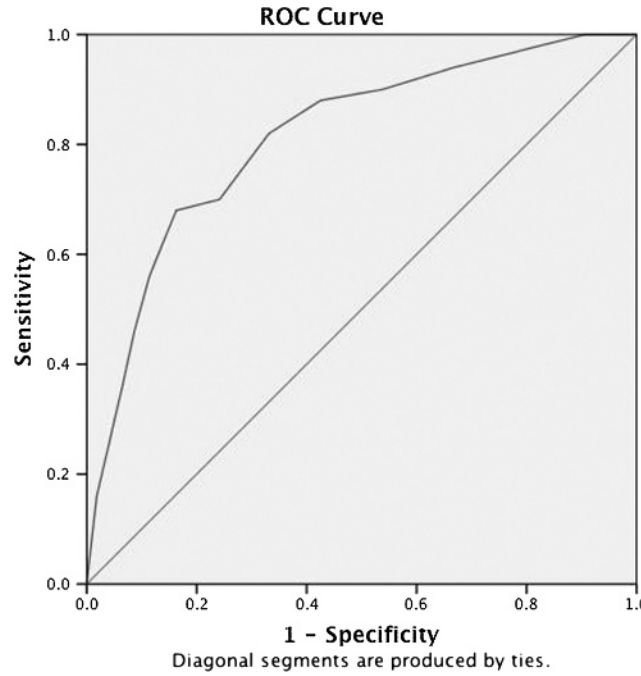

Figure 3. Receiver operating characteristic curve for two-item metric (Morse Falls Scale low-risk patients). Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients labeled low falls risk on Morse Falls Scale.

The two-item score was most accurate with patients with brain injuries, followed by stroke patients. Although the metric was less accurate with other diagnostic groups, patients with brain injury and stroke patients comprise 22.8% and 39.1% of all fallers, respectively, in this data set. As patients with brain injury and stroke patients comprise only 8.9% and 19.4% of the total sample, the two-item score has the advantage of performing best with groups most likely to fall in rehabilitation settings (Salamon, Victory, & Bobay, 2012). Notably, differences between fallers and nonfallers also remained apparent when considering only groups of patients who received the same fall precautions (high or low), suggesting that the two-item metric provides predictive utility beyond that offered by the MFS. The toileting/expression sum was less effective for orthopedic, cardiac, and pulmonary patients, which

Table 4 Receiver operating characteristic curves for two-item metric, diagnostic categories

Source	Area Under Curve	*n*	95% CI	Sensitivity	Specificity
Stroke	.737	319	[0.661, 0.813]	.722	.647
Brain injury	.825	151	[0.747, 0.902]	.857	.746
Orthopedic	.712	509	[0.600, 0.824]	.733	.684
Medical[a]	.656	495	[0.508, 0.804]	.625	.616

[a]Includes cardiac, pulmonary, patients with debility, pain or circulatory disorders, or neoplasms.

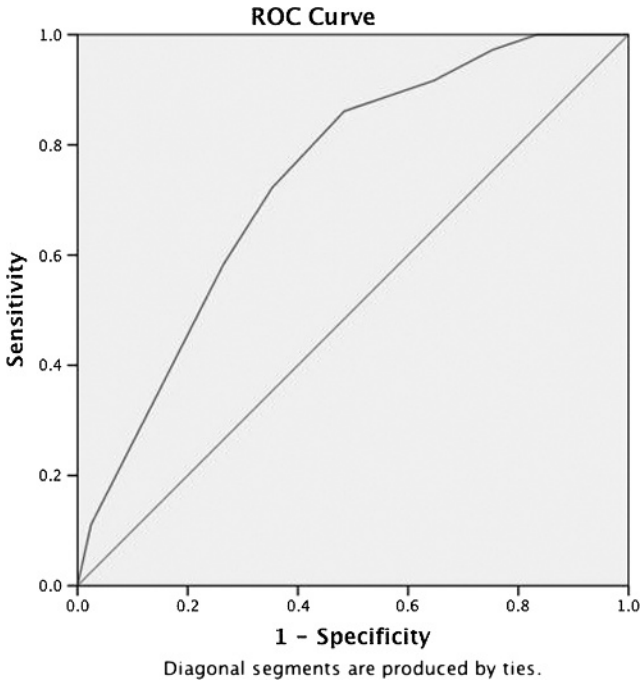

Figure 4. Receiver operating characteristic curve for stroke patients. Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients admitted after stroke.

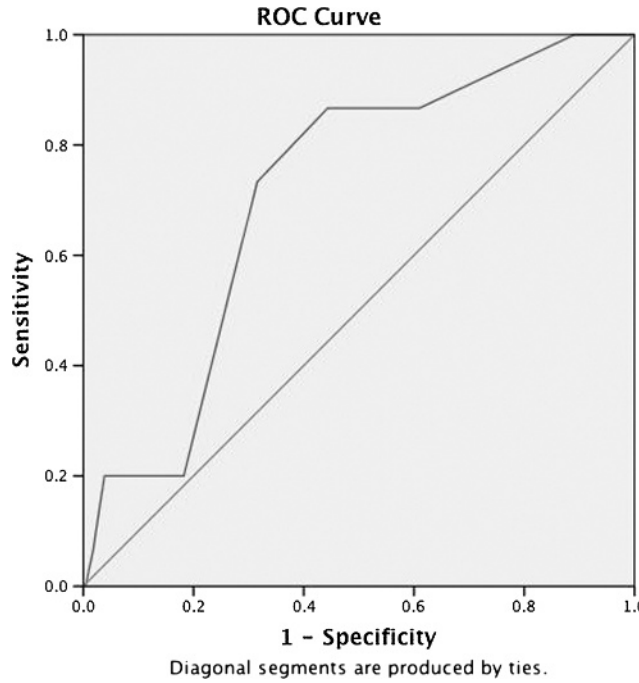

Figure 6. Receiver operating characteristic curve for orthopedic patients. Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients admitted with orthopedic diagnosis.

may suggest the potential utility of cohort-specific risk evaluation by IRF/Units.

The factors underlying the particular usefulness of the expression and toileting items are not clear. One explanation may be that patients requiring assistance with toileting (resulting in a low FIM score) frequently express embarrassment in requiring help with this activity and may become frustrated if assistance is not

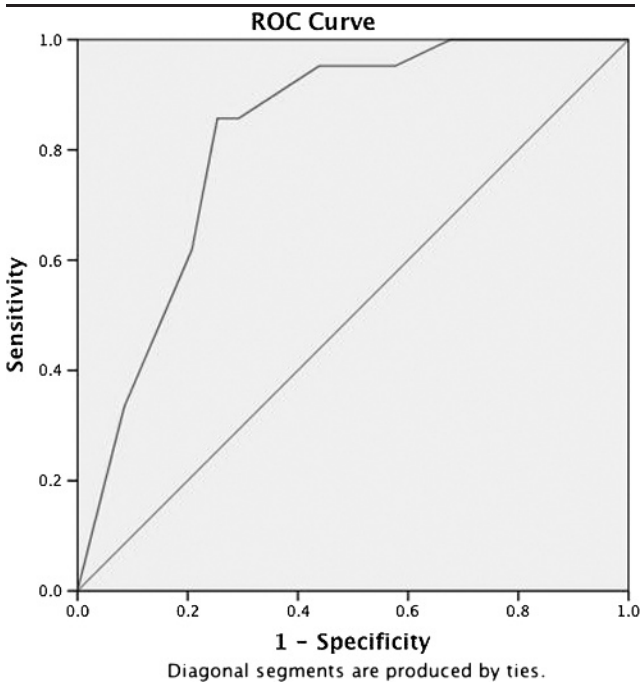

Figure 5. Receiver operating characteristic curve for patients with brain injury. Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients admitted after brain injury.

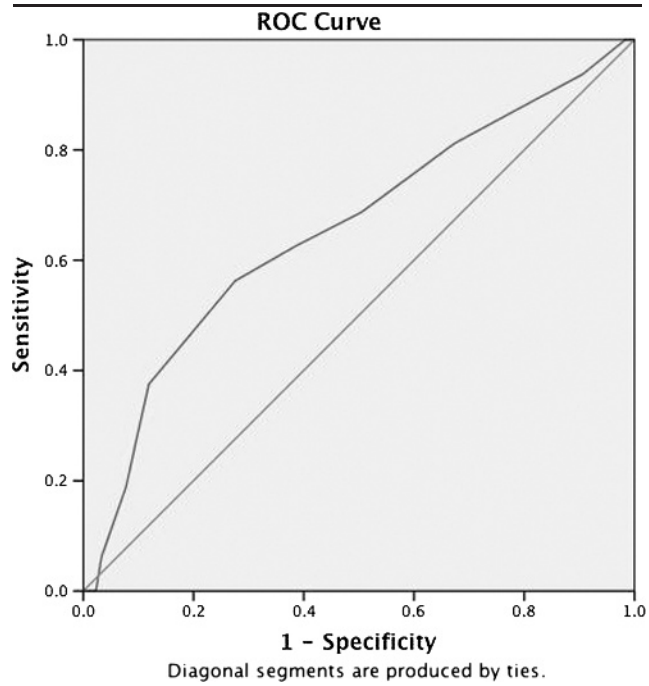

Figure 7. Receiver operating characteristic curve for medical patients. Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients admitted with medical diagnosis (cardiac, pulmonary, debility).

Table 5 Probability of falling

Score on Two-Item Metric	Probability of Falling
1	34.375
2	21.429
3	23.404
4	13.462
5	10.577
6	3.937
7	3.955
8	5.780
9	2.247
10	1.531
11	1.449
12	1.111
13	0
14	0

immediately available, resulting in an attempt to perform the activity independently. The relationship between expressive ability and falls could reflect a more general language component. Patients with low expressive scores may have difficulty expressing their wants or needs (e.g., needing to use the bathroom), as well as difficulty in understanding restrictions placed on their mobility by clinical staff.

Although previous research has suggested a nonlinear relationship between total FIM and likelihood of falling, this was not the case for the two-item metric (Petitpierre, et. al., 2010). A previous study concluded that patients scoring among the lowest possible values

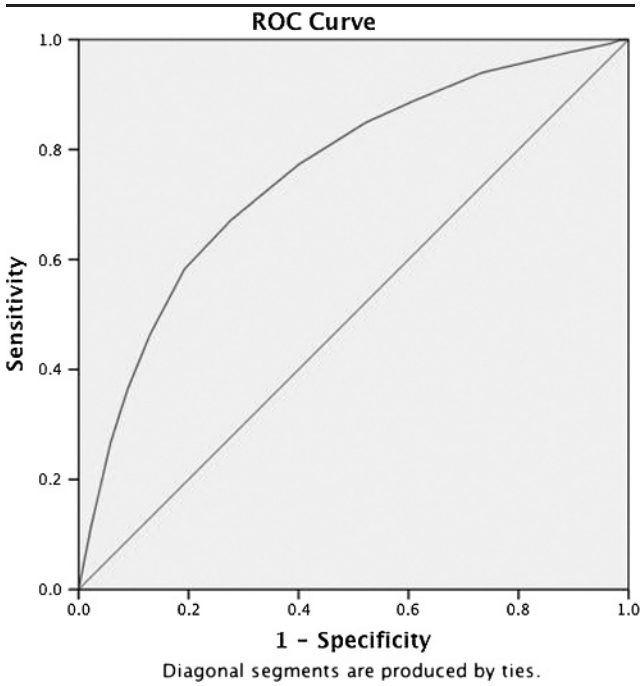

Figure 8. Receiver operating characteristic curve for historical validation. Plot of respective sensitivities and specificities for each possible cutoff value for two-item Toileting/Expression metric for patients admitted over a 5-year period, September 2008 to September 2013.

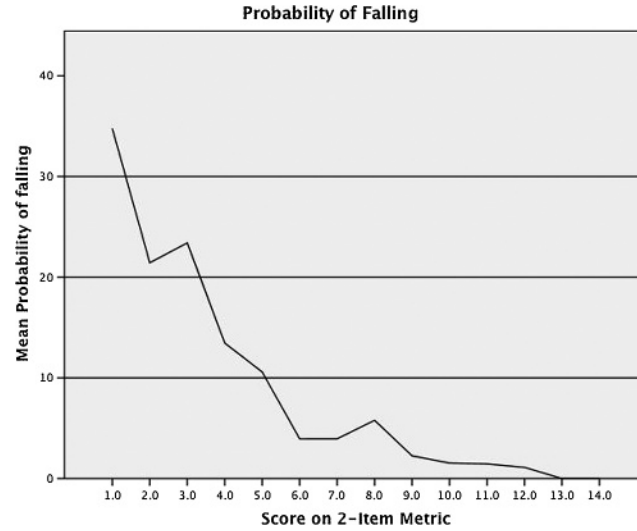

Figure 9. Plot of fall probabilities. Plot of probabilities of falling (*y* axis) for each possible value on two-item Toileting/Expression metric (*x* axis).

may be at a reduced risk of falling, possibly due to their reduced mobility or an increased level of assistance from caretakers (Suzuki et al., 2005). Although the relationship between the total FIM score at admission and the probability of falling was reasonably strong in both the 9-month and 5-year samples ($r = -.687$, $r = -.838$), the relationship between scores on the two-item toileting/expression sum and the probability of falling was stronger still ($r = -.877$). Patients who are incontinent and have great difficulty expressing themselves may receive a total score of 1 on the two-item score, yet still be physically capable of ambulation and remain at greater risk for falling.

For patients in this study, the MFS performed poorly at predicting which individuals would fall, possibly due to the fact that three of the factors on the MFS (device, mobility, and cognitive impairment) are extremely common in the rehab setting. True positive rates closely approximated false positive rates at each possible cutoff score on the MFS. It must be noted, however, that patients scoring above a cutoff score on the MFS were treated as high risk, and preventative measures were implemented, so the data sets in this study included both patients who had received additional fall prevention practices and those who did not. This likely affected the false positive rate on the MFS (patients who were labeled as high risk but did not fall), which may simply be an indication that hospital safety practices were effective in preventing falls for truly high-risk patients.

Study Limitations

This study did not specifically address patients who fell multiple times. Patients are categorized either as fallers or nonfallers without distinguishing between single-incident fallers and multiple-incident fallers. Future research might address the relationship between a two-item or total FIM

metric and single versus multiple falls. Furthermore, we did not evaluate the change in toileting/expression relative to the occurrence of falls, as the exact scores at the time of the fall were not available. It is possible that some scores may have improved or worsened by the time of the fall. In practical terms, any potential instrument would require repeat administration to reflect changes in functional status to allow for the most up-to-date risk assessment. In practice, nurses or other clinical staff could potentially update patient scores in response to a change in function at weekly rounds or team conferences, or following a fall. Furthermore, although the two-item metric proposed in this study fared favorably against the MFS when used as a predictive tool, it was not compared against numerous other falls risk assessment tools, including those developed specifically for rehabilitation populations, to which the two-item metric bears greater similarity.

The findings of this study need to be externally validated. Although a second data set was used in this study to address the potential bias inherent to an autovalidated metric, a prospective validation at an alternate hospital would provide evidence for the generalizability of these findings (see Haines et al., 2007). Fortunately, given that all IRF/Units already currently utilize the FIM, this hypothesis could be quickly and easily tested at another facility. In addition, although sensitivities and specificities for this study's simple metric were demonstrably superior to the MFS, even higher values would be preferable to maximize safety and quality. It has been suggested elsewhere that both sensitivity and specificity of .8 are necessary for a new tool to be clinically useful, and no cutoff values on full or subsample in this study reached those benchmarks simultaneously (Gilewski et al., 2007). The hospital at which this research was conducted is in the process of integrating the findings from this study into a more complete falls risk instrument, data for which are currently being collected.

Conclusions

FIM scores on the Toileting and Expression subscales can be summed and used to predict falls as quickly as and more accurately than the MFS. Patients typically receive these FIM scores within hours of admission, making this metric a potentially viable solution for reducing falls in inpatient rehabilitation facilities.

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