A Method of Calculating Functional Independence Measure at Discharge from Functional Independence Measure Effectiveness Predicted by Multiple Regression Analysis Has a High Degree of Predictive Accuracy

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Background: Multiple linear regression analysis is often used to predict the outcome of stroke rehabilitation. However, the predictive accuracy may not be satisfactory. The objective of this study was to elucidate the predictive accuracy of a method of calculating motor Functional Independence Measure (mFIM) at discharge from mFIM effectiveness predicted by multiple regression analysis. *Methods:* The subjects were 505 patients with stroke who were hospitalized in a convalescent rehabilitation hospital. The formula "mFIM at discharge = mFIM effectiveness × (91 points − mFIM at admission) + mFIM at admission" was used. By including the predicted mFIM effectiveness obtained through multiple regression analysis in this formula, we obtained the predicted mFIM at discharge (A). We also used multiple regression analysis to directly predict mFIM at discharge (B). The correlation between the predicted and the measured values of mFIM at discharge was compared between A and B. *Result:* The correlation coefficients were .916 for A and .878 for B. *Conclusion:* Calculating mFIM at discharge from mFIM effectiveness predicted by multiple regression analysis had a higher degree of predictive accuracy of mFIM at discharge than that directly predicted. **Key Words:** Multiple linear regression analysis—predictive accuracy—FIM at discharge—FIM effectiveness—FIM gain.

Introduction

When predicting the degree of improvement on the Functional Independence Measure (FIM)[1] using multiple linear regression analysis, predictive accuracy differs, depending upon what is used as the dependent variable. According to a review conducted by Meyer et al,[2] the coefficient of determination R^2, which indicates how well the independent variables describe the dependent variable, is an average of .65 (minimum of .35 to maximum of .82) when the dependent variable is FIM at discharge, an average of .22 (.08-.4) when the dependent variable is FIM gain (FIM at discharge − FIM at admission), and an average of .08 (.03-.14) when the dependent variable is FIM efficiency (FIM gain/number of days in the hospital). Due to its high R^2 figure, FIM at discharge is used as the dependent variable in a large number of studies. Specifically, a review of multiple regression analyses conducted on patients in the acute phase of stroke[2] indicated that 33 prediction formulae used FIM at discharge as the dependent variable, 20 prediction formulae used FIM gain as the dependent variable, and 3

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prediction formulae used FIM efficiency as the dependent variable. However, none used FIM effectiveness[3,4] as the dependent variable.

However, the following 2 points have been reported in regard to the predictive accuracy of multiple regression analysis: (1) Because "motor Functional Independence Measure (mFIM) at discharge = mFIM at admission + mFIM gain," mFIM at discharge, which has a high R^2 value, was first predicted using multiple regression analysis. Then, by subtracting mFIM at admission from the predicted mFIM at discharge, the mFIM gain was predicted. The correlation between the measured and the predicted values of mFIM gain ended up being the same low figure as when directly predicting mFIM gain using multiple regression analysis.[5] In other words, although the value for R^2 when the dependent variable is mFIM at discharge is high, the predictive accuracy for mFIM at discharge and the predictive accuracy for mFIM gain will essentially be the same. (2) The reported R^2 values when mFIM effectiveness was used as the dependent variable were .35[6] and .419,[7] respectively. In other words, the predictive accuracy of mFIM effectiveness may be higher than the predictive accuracy of mFIM gain.

From the above, we devised the following hypothesis: first, multiple regression analysis is used to predict mFIM effectiveness. Because "mFIM effectiveness = mFIM gain/(91 points − mFIM at admission)," by calculating "mFIM gain = mFIM effectiveness × (91 points − mFIM at admission)," we can obtain the predicted mFIM gain. By adding mFIM at admission to this predicted mFIM gain, we are then able to obtain the predicted mFIM at discharge. The mFIM at discharge that we obtain in this way may have a higher predictive accuracy than mFIM at discharge directly predicted by multiple regression analysis.

The purpose of the present study was to compare the predictive accuracy of mFIM at discharge calculated from mFIM effectiveness predicted by multiple regression analysis to that of mFIM at discharge directly predicted by multiple regression analysis.

Methods

Subjects

A total of 770 patients with stroke who were admitted to the convalescent rehabilitation ward in Kumamoto Kinoh Hospital between April 1, 2013, and June 17, 2016, after undergoing treatment at acute care hospitals were enrolled in the study. The following patients were excluded: those with subarachnoid hemorrhage (60 cases), those aged younger than 40 years old (29 cases), those who died in the hospital (5 cases), those whose outcome was not recorded (7 cases), those admitted within 6 days or more than 61 days after onset (45 cases), those who spent less than 31 days in the hospital (91 cases), those whose FIM score at admission or discharge was not recorded (2 cases), those who were readmitted (13 cases), those whose mFIM score at admission was 91 points (4 cases), and those whose mFIM gain was less than 0 point (9 cases). The remaining 505 patients were included in this study.

Investigation 1. Multiple Regression Analysis with mFIM at Discharge, mFIM Gain, and mFIM Effectiveness Used as the Dependent Variable

We performed multiple regression analysis with mFIM at discharge, mFIM gain, and mFIM effectiveness used as the dependent variables. The independent variables were the following 6 items: age, sex, type of stroke (cerebral infarction or cerebral hemorrhage), number of days from onset to admission, mFIM score at admission, and cognitive FIM score at admission.

Investigation 2. Conversion from mFIM Effectiveness to mFIM Gain and from mFIM Gain to mFIM at Discharge

The formula mFIM gain = mFIM effectiveness × (91 points − mFIM at admission) was used. This formula allowed us to obtain the predicted mFIM gain by including the predicted mFIM effectiveness obtained from the multiple regression analysis. Another formula was mFIM at discharge = mFIM at admission + mFIM gain. By including the predicted mFIM gain to this formula, we were able to obtain the predicted mFIM at discharge.

We then examined the correlation between the measured and the predicted values obtained from investigations 1 and 2 as well as the residual error, obtained by subtracting the predicted value from the measured value. Correlations were calculated using Pearson's correlation coefficient test.

The present study complied with the regulations of the Clinical Research Ethics Committee of the authors' hospital. All personal data were processed so as not to identify any individuals. The statistics software we used was 4 Steps Excel Statistics (OMS Publishing, Tokorozawa, Saitama, Japan).[8]

Results

Table 1 shows the basic attributes of the 505 subjects. Other than a shorter period between onset and admission, the subjects were very similar to those recorded in the national survey of convalescent rehabilitation wards in Japan.[9]

When the dependent variables were mFIM at discharge, mFIM gain, and mFIM effectiveness, the coefficients of determination, R^2, were .771, .399, and .543, respectively (Table 2). The prediction formula for mFIM effectiveness was .0114 × cognitive FIM at admission − .0075 × age + .0028 × mFIM at admission − .0049 × number of days from onset to admission − .0792 × female + .0435 × hemorrhage + .802.

The correlation coefficients for the measured and the predicted values of mFIM at discharge (model 1), mFIM