Japanese Journal of Comprehensive Rehabilitation Science (2020)

Original Article

Comparison of the accuracy of multiple regression analysis using four methods to predict the functional independence measure at discharge

Makoto Tokunaga, MD, PhD,[1] Hiroaki Yamanaga, MD, PhD[1]

[1]Department of Rehabilitation Medicine, Kumamoto Kinoh Hospital, Kumamoto, Japan

ABSTRACT

Tokunaga M, Yamanaga H. Comparison of the accuracy of multiple regression analysis using four methods to predict the functional independence measure at discharge. Jpn J Compr Rehabil Sci 2020; 11: 65−72.

Objective: This study aims to compare the accuracy of four methods of multiple regression analysis in predicting the motor functional independence measure (mFIM) at discharge.

Methods: The subjects of this study were 1,064 stroke patients who had been hospitalized in a convalescent rehabilitation hospital. Standard multiple regression analysis (S prediction) with mFIM at discharge as the objective variable, multiple regression analysis with reciprocal number of mFIM at admission as one of the explanatory variables (R prediction), prediction of the effectiveness of mFIM by multiple regression analysis, the conversion to mFIM at discharge (E prediction), and the creation of two multiple regression prediction formulas (S2 prediction) were performed. The absolute values of residuals (actual value minus predicted value) of mFIM at discharge were compared for the four methods.

Results: The absolute value of the residuals was significantly smaller in the R prediction, E prediction, and S2 prediction than that in the S prediction. In addition, the absolute value was found to be significantly smaller in the E prediction and S2 prediction than that in the R prediction.

Conclusion: In multiple regression analysis, the use of E prediction or S2 prediction is recommended because of their high prediction accuracies.

Correspondence: Makoto Tokunaga, MD, PhD
Department of Rehabilitation Medicine, Kumamoto Kinoh Hospital, 6−8−1 Yamamuro, Kita-ku, Kumamoto 860−8518, Japan.
E-mail: tokunaga@juryo.or.jp

Accepted: April 6, 2020.
No benefits in any form have been or will be received from any commercial party related directly or indirectly to the subject of this manuscript.

doi.org/10.11336/jjcrs.11.65

Key words: multiple regression analysis, prediction accuracy, reciprocal number, FIM effectiveness, multiple prediction formulas

Introduction

Prediction of outcome is important for planning and executing treatment plans during rehabilitation. Multiple regression analysis aims to not only predict outcomes such as functional independence measure (FIM) [1] at discharge and FIM gain (FIM at discharge minus FIM at admission) but also identify the factors affecting the outcome. Many previous reports have used multiple regression analysis [2−4].

However, the accuracy of prediction by multiple regression analysis is not as high as expected. Meyer et al. [4] studied multiple regression analysis and reported that the coefficient of determination (R^2), which means the extent to which the explanatory variables can explain the objective variable, was an average of 0.65 (minimum 0.35 to maximum 0.82) in the prediction of FIM at discharge. In the prediction of FIM gain, R^2 was found to be an average of 0.22 (minimum 0.08 to maximum 0.4). The reasons for the low accuracy of prediction by multiple regression analysis are as follows. 1) Multiple regression analysis assumes that there is a linear relationship between the explanatory variables and objective variable, but this is not always true. 2) Since the FIM gain has a ceiling effect (meaning that the FIM gain is small for patients with high FIM scores at admission), the effect of factors on FIM gain is strongly affected by FIM scores at admission. 3) Multiple regression analysis is a method of adding the effects of factors. 4) Factors other than those used for explanatory variables affect FIM at discharge [5].

To improve the accuracy of prediction of motor FIM (mFIM) at discharge by multiple regression analysis, three methods can be used: 1) converting the mFIM at admission to a reciprocal number (1/mFIM at admission) and using it as one of the explanatory variables [6], 2) predicting the effectiveness of mFIM

by multiple regression analysis and converting it to mFIM at discharge [7], and 3) creating two prediction formulas using the data of patients with low and high mFIM at admission [8, 9]. These methods have been found to have a higher accuracy than that of standard multiple regression analysis. However, a comparison of the accuracy of prediction by these three methods has not been made.

Wada et al. [10] compared the accuracy of prediction of the standard multiple regression analysis (S prediction) method, the method of converting the mFIM at admission to a reciprocal number (R prediction), and the method of predicting the effectiveness of mFIM by multiple regression analysis and then converting it to the mFIM at discharge (E prediction). The absolute value of the residuals (actual value minus predicted value) of mFIM at discharge was significantly smaller in the R prediction (7.30 ± 6.56) and E prediction (7.56 ± 6.45) than that in the S prediction (9.38 ± 6.62) [10]. However, Wada et al. [10] did not investigate the accuracy of prediction of the method of creating two prediction formulas (S2 prediction).

In this study, we performed S prediction, R prediction, E prediction, and S2 prediction to determine the method with the highest prediction accuracy by comparing the absolute values of the residuals of the four methods.

Subjects and methods

The subjects consisted of stroke patients who had been discharged from the convalescent rehabilitation ward in K hospital between April 1, 2013 and March 31, 2019. The following patients were excluded to eliminate the effects of exceptional patients: those with subarachnoid hemorrhage, those who had been admitted within 4 d or more than 60 d after onset, those who had spent less than 30 d or more than 180 d in the hospital, those with mFIM score of 91 points at admission, and those with mFIM gain of less than 0 point. A total of 1,064 patients were included in the present study.

1. S prediction, R prediction, and E prediction

Similar to previous studies [7, 10], age, number of days from onset to admission, mFIM at admission, cognitive FIM at admission, sex, and type of stroke were defined as the explanatory variables in the S prediction. Sex and type of stroke were defined as the dummy variables (male 0, female 1, cerebral hemorrhage 0, cerebral infarction 1). Multiple regression analysis using the forced input method was performed. The mFIM at discharge was defined as the objective variable. In the R prediction, "1/mFIM at admission" was defined as one of the explanatory variables instead of mFIM at admission [6]. In the E prediction, the same explanatory variables as those in the S prediction were defined, while mFIM effectiveness was defined as the objective variable where mFIM effectiveness = mFIM gain/(91 points − mFIM score at admission) [11]. Therefore, FIM gain was expressed by the equation: FIM gain = mFIM effectiveness × (91 points − mFIM score at admission), and the mFIM at discharge was described by the equation: mFIM at discharge = mFIM gain + mFIM at admission. Therefore, the predicted value of mFIM at discharge was obtained using the formula: mFIM at discharge = predicted value of mFIM effectiveness × (91 points − mFIM score at admission) + mFIM score at admission [7].

2. S2 prediction

The median mFIM gain of stroke patients in the convalescent rehabilitation ward was found to have a convex shape with a peak of approximately 40 points of mFIM at admission [12]. Therefore, mFIM at admission was divided into two groups: 13−39 points (low mFIM group) and 40−90 points (high mFIM group). Multiple regression analysis was performed in the S2 prediction, and two prediction formulas were computed using the patients' data of the low mFIM group and the high mFIM group (S2 prediction).

3. Comparison of absolute values of the residuals

To compare the accuracy of the prediction formulas, we investigated the absolute values of the residuals of mFIM at discharge similar to the previous study by Wada et al. [10]. In the four prediction methods (i.e., S, R, E, and S2 predictions), the absolute values of the residuals were obtained not only for all patients but also for the low and high mFIM groups. The main statistical tool used was the Kruskal-Wallis test, and when there was a significant difference, multiple comparisons were made using the Steel-Dwass method. The significance level was found to be less than 5%.

This study complied with the regulations of the Clinical Research Ethics Committee of the authors' hospital (approval number: JMC302-1936). All personal data were processed in a manner that protected the anonymity of the subjects. The statistical software used was 4 Steps Excel Statistics [13].

Results

Table 1 shows the basic attribute data of the 1,064 target patients with 430 patients in the low mFIM at admission group and 634 patients in the high mFIM at admission group. The median mFIM effectiveness is 0.336 in the low mFIM group and 0.750 in the high mFIM group. The median mFIM gain is 23 points in the low mFIM group and 18 points in the high mFIM group, which is smaller than that in the low mFIM group due to the ceiling effect.

Table 2 shows the prediction formula for the multiple regression analysis. R^2 is 0.813 for R prediction, 0.757 for S prediction, 0.522 for E prediction, and 0.621 for the low mFIM group and 0.540 for the high mFIM

group in the S2 prediction. Thus, R^2 was the highest in the R prediction.

Figure 1 shows the relationship between the measured and predicted values of mFIM at discharge. The absolute

Table 1. The basic attribute data of the subjects.

	Target patients	Low mFIM group	High mFIM group
Number of patients	1,064	430	634
Infarction, hemorrhage	400, 664	213, 217	187, 447
Sex	Male 618, female 446	Male 236, female 194	Male 382, female 252
Age	69.7±13.6 (71)	72.8±13.0 (75)	67.7±13.7 (69)
Number of days from onset to admission	17.8±9.7 (15)	19.2±9.9 (17)	16.8±9.5 (14)
Number of days in hospital	90.0±37.6 (89)	112.9±31.4 (116.5)	74.4±33.1 (68.5)
Motor FIM score at admission	46.5±24.5 (47)	21.0±8.7 (17)	63.8±14.6 (63)
Cognitive FIM score at admission	22.7±8.9 (24)	15.6±7.8 (14.5)	27.5±5.9 (29)
Motor FIM score at discharge	67.4±24.2 (77)	45.4±22.9 (43.5)	82.3±8.8 (85)
Cognitive FIM score at discharge	26.8±8.1 (29)	20.9±8.6 (21)	30.8±4.7 (32)
Motor FIM gain	20.9±15.1 (19)	24.4±18.7 (23)	18.5±11.3 (18)
Motor FIM effectiveness	0.565±0.309 (0.631)	0.365±0.284 (0.336)	0.701±0.244 (0.750)

Abbreviation: FIM, Functional Independence Measure.
Data for this study are expressed as number of patients or mean±standard deviation (median value).
Low mFIM group, mFIM at admission of 13−39 points; high mFIM group, mFIM at admission of 40−90 points.

Table 2. The prediction formula for the multiple regression analysis.

Motor FIM score at admission	S prediction 13−90 points	R prediction 13−90 points	E prediction 13−90 points	S2 prediction	
				13−39 points	40−90 points
Number of patients	1,064	1,064	1,064	430	634
Explanatory variables					
Age	−0.299	−0.322	−0.00664	−0.619	−0.147
Days from onset to admission	−0.233	−0.229	−0.00490	−0.400	−0.116
Motor FIM score at admission	0.547	—	0.00333	0.992	0.331
1 / motor FIM score at admission	—	−738.354	—	—	—
Cognitive FIM score at admission	0.799	0.411	0.01054	0.783	0.233
Sex (male 0, female 1)	−1.551	−1.497	−0.04798	−3.854	−1.362
Stroke type (hemorrhage 0, infarction 1)	−2.226	−1.800	−0.03719	−0.343	−2.007
Constants	50.8	110.2	0.765	67.1	68.6
Coefficient of determination R^2	0.757	0.813	0.522	0.621	0.540

Numerical value, partial regression coefficient.
The predicted value for mFIM at discharge in S prediction = −0.299 × age −0.233 × days from onset to admission + 0.547 × mFIM at admission + 0.799 × cognitive FIM at admission −1.551 × (male 0, female 1) −2.226 × (hemorrhage 0, infarction 1) + 50.8.

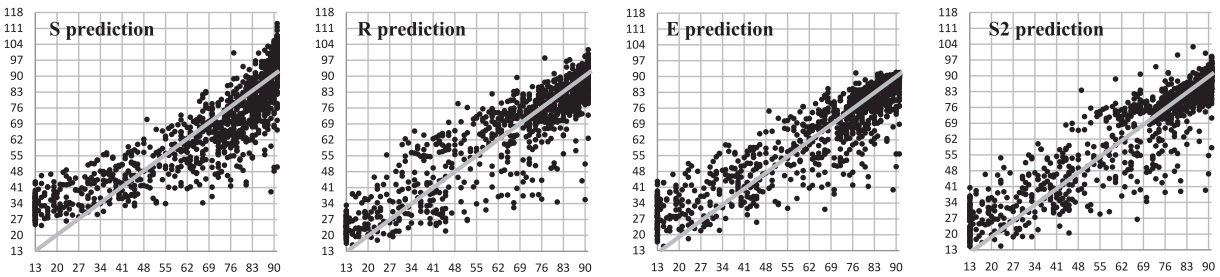

Figure 1. Scatter diagram.
Dot, Each patient; horizontal axis, measured value of motor FIM at discharge; vertical axis, predicted value of motor FIM at discharge.

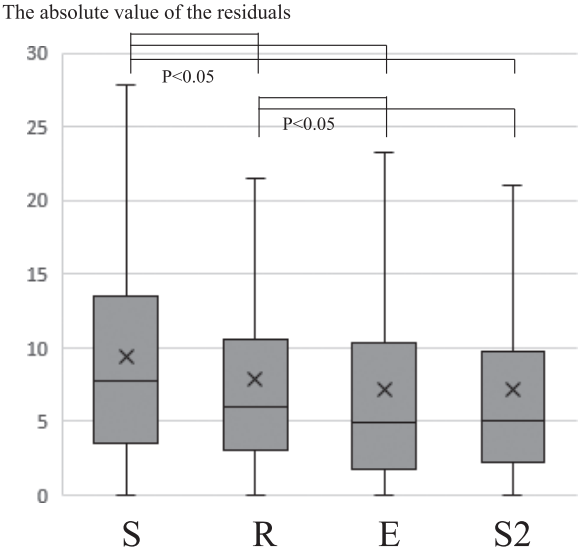

Figure 2. Comparison of residuals between predictions. Box, 25%tile to 75%tile; horizontal bar, median; ×, mean.

value of the residuals of mFIM at discharge was 9.4 ± 7.4 (median 7.8) for S prediction, 7.8 ± 6.9 (median 6.0) for R prediction, 7.2 ± 7.1 (median 5.0) for E prediction, and 7.2 ± 7.0 (median 5.0) for S2 prediction, showing a significant difference among the four methods. Multiple comparison analysis shows significant differences between S prediction and R prediction/E prediction/S2 prediction and between R prediction and E prediction/S2 prediction (Figure 2).

Figure 3 shows the relationship between the measured and the predicted values of mFIM at discharge, divided into the low mFIM group (13−39 points) and high mFIM group (40−90 points). In the low mFIM group, the absolute value of the residuals of mFIM at discharge is 13.0 ± 8.6 (median 12.0) for S prediction, 11.5 ± 8.6 (median 9.4) for R prediction, 11.6 ± 8.3 (median 10.2) for E prediction, and 11.2 ± 8.5 (median 9.4) for S2 prediction, showing significant differences among the four methods. Multiple comparison analysis shows significant differences between S prediction and R prediction/S2 prediction (Figure 4a).

In the high mFIM group, the absolute value of the residuals of mFIM at discharge is 6.9 ± 5.2 (median 5.8) for S prediction, 5.4 ± 4.0 (median 4.6) for R prediction, 4.2 ± 4.0 (median 2.9) for E prediction, and 4.5 ± 4.0 (median 3.4) for S2 prediction, showing a significant difference among the four methods. Multiple comparison analysis shows significant differences between S prediction and R prediction/E prediction/S2 prediction and between R prediction and E prediction/S2 prediction (Figure 4b).

Discussion

R^2 is often used as an indicator of the accuracy of a prediction equation. However, it cannot be concluded that the accuracy of prediction is as high as that of the prediction equation with a high R^2 described in the study. This is because 1) the accuracy of prediction is not always high in groups other than the target group and 2) R^2 is not always the most precise indicator of the accuracy of prediction. Regarding the former, it is necessary to evaluate the external validity of the prediction formula [14]. For the latter, R^2 is 0.65 on average when FIM at discharge is the objective variable and higher than the average of 0.22 when FIM gain is the objective variable [4]. Since mFIM at discharge = mFIM at admission + mFIM gain, mFIM at discharge with high R^2 was predicted by multiple regression analysis, and the mFIM at admission was subtracted from the predicted value of mFIM at discharge to obtain the predicted value of mFIM gain. The correlation between the measured and the predicted value of mFIM gain obtained by this method was the same as that of when the mFIM gain was predicted directly by multiple regression analysis [15]. That is, when mFIM at discharge is the objective variable, R^2 is large only in appearance, and the prediction accuracy of mFIM at discharge and the prediction accuracy of mFIM gain are the same. Furthermore, when mFIM effectiveness was the objective variable, R^2 was 0.54, which was smaller than the R^2 of 0.77 when mFIM at discharge was the objective variable [7]. Further, when the predicted value of mFIM at discharge was calculated using the formula: mFIM at discharge = predicted mFIM effectiveness × (91 points − mFIM at admission) + mFIM at admission, the correlation coefficient between the measured value and the predicted value of mFIM at discharge was as high as 0.916, which was higher than the correlation coefficient of 0.878 when mFIM at discharge was predicted directly by multiple regression analysis [7]. That is, the accuracy of prediction by multiple regression analysis using mFIM effectiveness as the objective variable is higher than that when using mFIM at discharge as the objective variable. This indicates that the accuracy of prediction cannot be evaluated correctly using R^2. Thus, Wada et al. [10] compared the accuracy of the prediction formulas with the absolute value of the residuals obtained by subtracting the predicted value from the measured value of the mFIM at discharge. We used the same method in this study.

The findings of this study indicated that the accuracy of R prediction, E prediction, and S2 prediction was significantly higher than that of the standard S prediction, and the accuracy of E prediction and S2 prediction was significantly higher than that of R prediction. Therefore, we recommend using E prediction or S2 prediction in multiple regression analysis for the accurate prediction of mFIM at discharge.

The accuracy of R prediction and E prediction was significantly higher than that of the standard S prediction, which is in good agreement with the

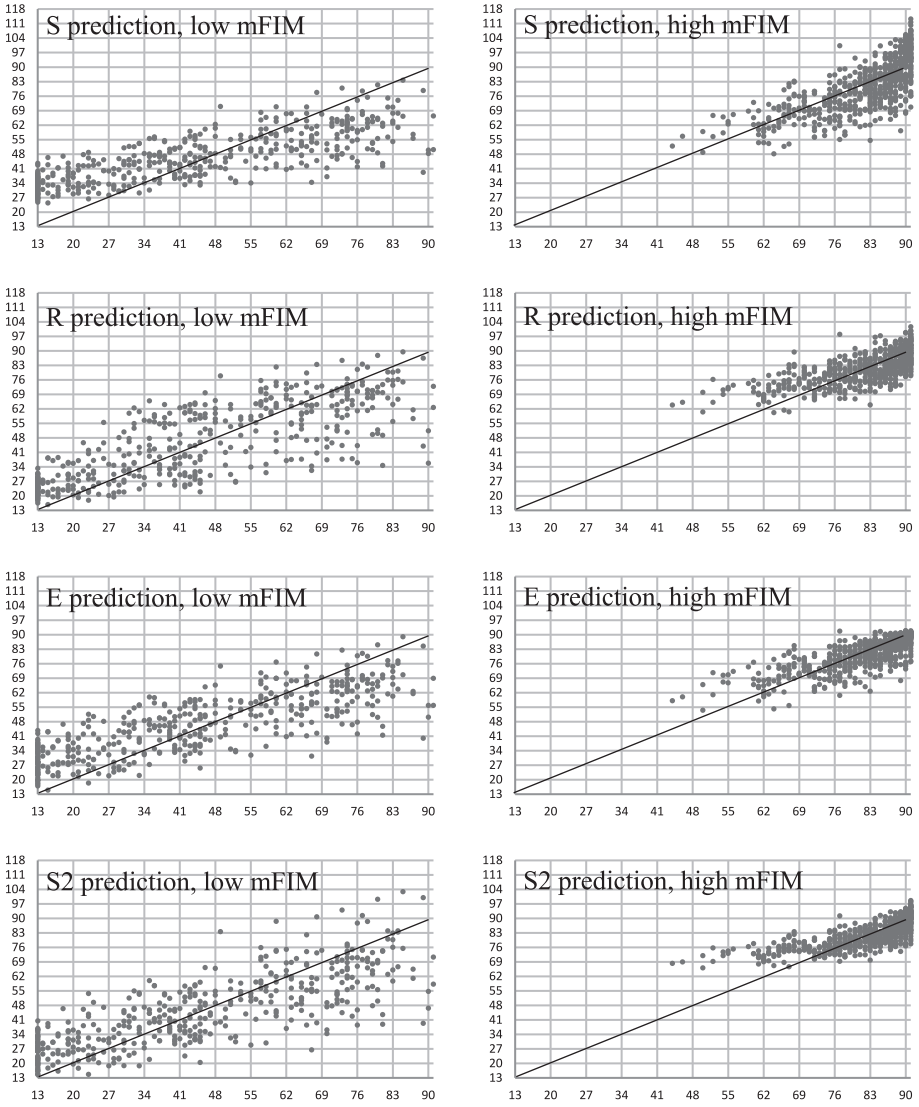

Figure 3. Scatter diagram divided into the low mFIM group and high mFIM group.
Horizontal axis, Measured value of mFIM at discharge; Vertical axis, Predicted value of mFIM at discharge.
Low mFIM, mFIM at admission of 13−39 points; High mFIM, mFIM at admission of 40−90 points.

findings of Wada et al. [10]. Wada et al. [10] concluded that the accuracy of R prediction and E prediction was higher than that of S prediction because the ceiling effect was corrected in the R prediction and E prediction methods [10]. The ceiling effect implies that the mFIM gain is low for patients with a high mFIM at admission. In S2 prediction, the partial regression coefficient of mFIM at admission is 0.992 in the low mFIM group and 0.331 in the high mFIM group (Table 2). This is because mFIM gain has a convex shape with a peak of approximately 40 points of mFIM at admission [12]. When plotting mFIM at admission on the horizontal axis and mFIM at discharge on the vertical axis, if mFIM gain is 0 points for all patients, the mFIM at discharge is the hypotenuse of a right-angled isosceles triangle. When the mFIM gain, which has a peak of approximately 40 points of mFIM at admission, was added to this hypotenuse, the partial regression coefficient of mFIM at admission increased to 0.992 in the low mFIM group. This means that mFIM at discharge increases by 0.992 points as mFIM admission increases by one point. Moreover, in the high mFIM group, which has a ceiling effect, the partial regression coefficient of mFIM at admission was as small as 0.331. In the case of S prediction, which only computed one prediction formula, the partial regression coefficient of mFIM at admission was 0.547, which is an intermediate value between 0.992 and 0.331. In this case, the predicted mFIM at discharge becomes too large for patients with mFIM at admission of approximately 90 points in the S prediction (Figure 3). In R prediction, the reciprocal of mFIM at admission is close to 0; therefore, the predicted value of mFIM at discharge in the high

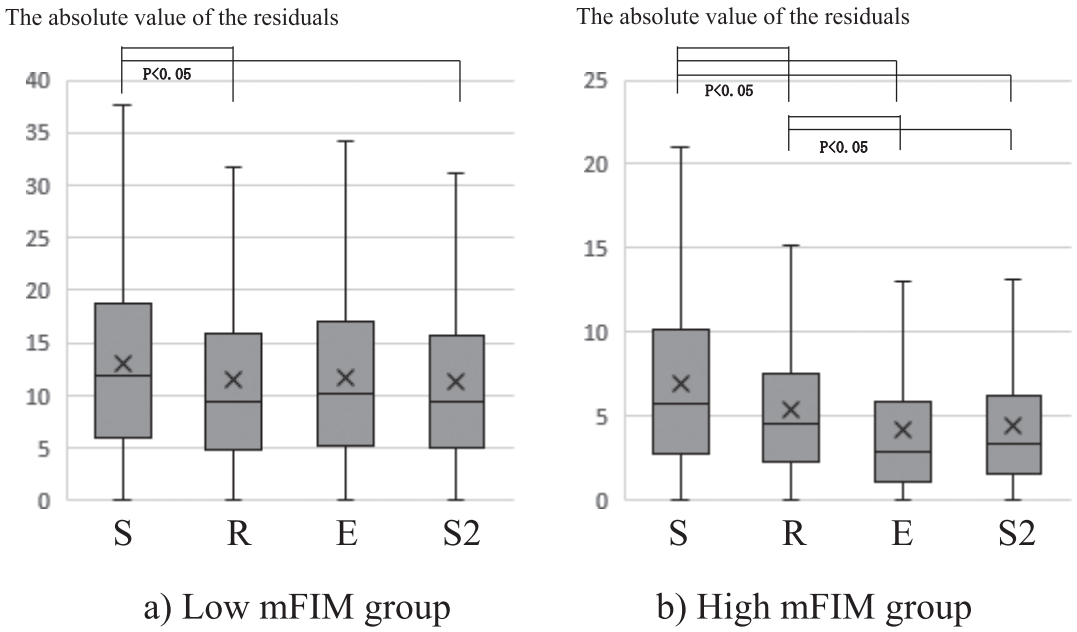

Figure 4. Comparison of residuals divided by low and high mFIM groups.

mFIM group does not become too large. The E prediction uses the formula: mFIM at discharge = predicted value of mFIM effectiveness × (91 points − mFIM score at admission) + mFIM score at admission. In the high mFIM group, 91 points − mFIM score at admission is close to 0. Therefore, the predicted value of mFIM at discharge in the high mFIM group does not become too large in the E prediction.

In this study, unlike the report of Wada et al. [10], the accuracy of E prediction was found to be significantly higher than that of R prediction. To investigate this difference in the accuracy of prediction, we stratified mFIM at admission into a low mFIM group and a high mFIM group. In the low mFIM group, there was no significant difference in the accuracy of R prediction and E prediction, whereas in the high mFIM group, the accuracy of E prediction was significantly higher than that of R prediction. Therefore, when the target patients include many high mFIM patients, a significant difference was detected between E prediction and R prediction. When the target patients included many low mFIM patients, there was no significant difference between E prediction and R prediction.

Previous studies have shown that S2 prediction has higher prediction accuracy than that of the standard S prediction [8, 9, 15]. However, the previous studies did not compare the accuracy of S2 prediction, R prediction, or E prediction. This study revealed that there was no significant difference between S2 prediction and E prediction, but S2 prediction was found have a significantly higher accuracy than R prediction.

The factors that should be stratified when creating multiple prediction formulas include the mFIM at admission and the cognitive FIM at admission [15]. Age, modified Rankin Scale before onset, and number of days from onset to admission can be inputted as explanatory variables without stratification [15]. Explanatory variables that should be stratified, such as mFIM at admission, are variables that have a strong influence on the objective variable and lack a linear relationship with the objective variable. Another reason for creating multiple prediction formulas is that the magnitude of the effect of explanatory variables on mFIM at discharge varies with the patient group. This is because rehabilitation inhibitors do not affect all patients uniformly [16, 17]. However, if too many prediction formulas are created, the analysis becomes complicated.

Although we did not examine which factors should be used as explanatory variables in this study, it is extremely important to select appropriate explanatory variables to improve the accuracy of prediction by multiple regression analysis [4, 18].

In most of the previous reports using multiple regression analysis, the standard method (S prediction) was selected. Notably, the prediction results obtained by methods with low accuracy are inevitably unreliable. Hence, the prediction accuracy of multiple regression analysis must be improved. Moreover, it is necessary to identify a method with a high accuracy of prediction by directly comparing the accuracy of the selected prediction methods.

The limitations of this study are as follows. First, we excluded patients with a hospital stay of less than 29 days, more than 181 days, and a negative mFIM gain to eliminate the effects of exceptional patients. However, this information was not obtained at the time of admission. A review of multiple regression analysis predicting FIM improvement in stroke patients admitted to convalescent rehabilitation wards

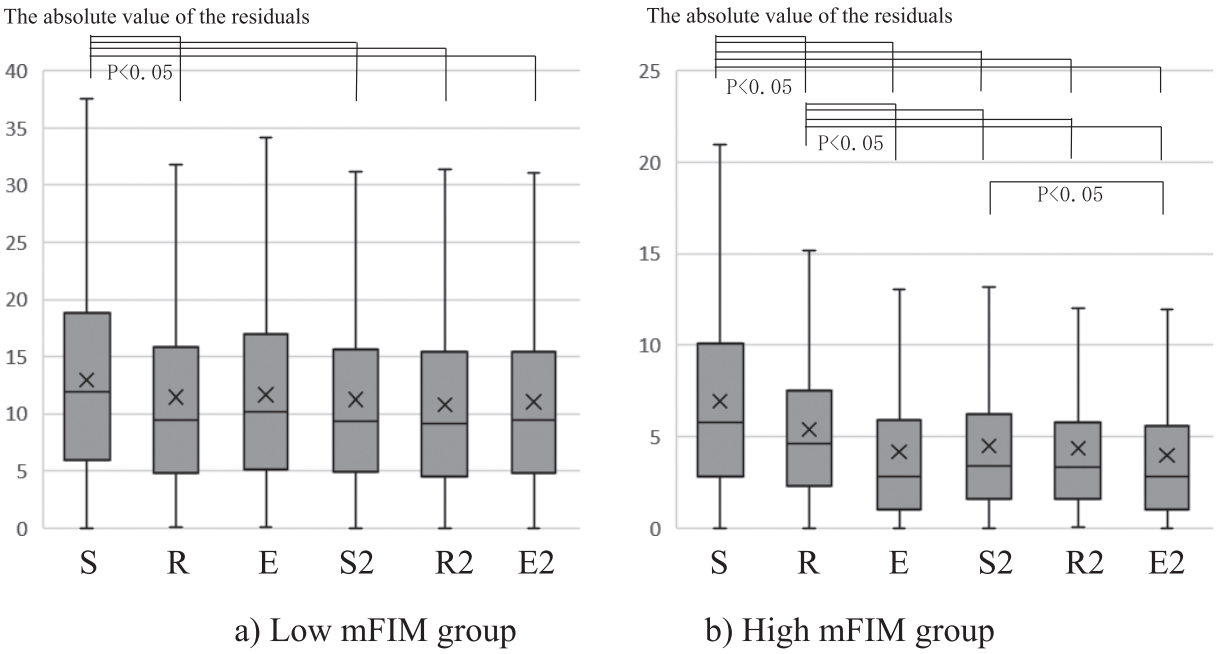

Figure 5. Comparison of residuals in six prediction formulas.
Significant differences were observed between S and R/E/S2/E2, between R and E/S2/R2/E2, and between S2 and E2.

in Japan showed that, in one study, the purpose of performing multiple regression analysis was to compute a prediction formula and, in another 18 studies, the purpose was to investigate the influence of factors on FIM improvement [18]. In the first study, the data obtained at the time of admission were defined as the explanatory variables. In contrast, in the 18 studies, the data defined as the explanatory variables included the length of hospital stay and nutritional improvement [18]. The second limitation of this study is that in R prediction and E prediction, even if two prediction formulas are computed (R2 prediction and E2 prediction), the accuracy of prediction does not improve significantly (Figure 5). This indicates that there are limitations when various methods are combined to reduce the ceiling effect. The third important limitation of this study is that although the prediction accuracy was improved by reducing the ceiling effect by R prediction, E prediction, and S2 prediction in the high mFIM group, these methods had no effect on the low mFIM group. Thus, other methods, such as using appropriate explanatory variables, are necessary.

References

1. Data management service of the Uniform Data System for Medical Rehabilitation and the Center for Functional Assessment Research: Guideline for use of the Uniform Data Set for Medical Rehabilitation. Version 3.1, State University of New York at Buffalo, Buffalo, 1990.
2. Heinemann AW, Linacre JM, Wright BD, Hamilton BB, Granger C. Prediction of rehabilitation outcomes with disability measures. Arch Phy Med Rehabil 1994; 75: 133–43.
3. Chumney D, Nollinger K, Shesko K, Skop K, Spencer M, Newton RA. Ability of Functional Independence Measure to accurately predict functional outcome of stroke-specific population: systematic review. J Rehabil Res Dev 2010; 47: 17–29.
4. Meyer MJ, Pereira S, McClure A, Teasell R, Thind A, Koval J, et al. A systematic review of studies reporting multivariable models to predict functional outcomes after post-stroke inpatient rehabilitation. Disabil Rehabil 2015; 37: 1316–23.
5. Tokunaga M, Hashimoto Y, Watanabe S, Nakanishi R, Yamanaga H, Yonemitsu K, et al. Methods for improving the predictive accuracy using multiple linear regression analysis to predict the improvement degree of Functional Independence Measure for stroke patients. Int J Phys Med Rehabil 2017; 5: 414.
6. Sonoda S, Saitoh E, Nagai S, Okuyama Y, Suzuki T, Suzuki M. Stroke outcome prediction using reciprocal number of initial activities of daily living status. J stroke Cerebrovasc Dis 2005; 14: 8–11.
7. Tokunaga M, Watanabe S, Sonoda S. 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. J Stroke Cerebrovasc Dis 2017; 16: 1923–8.
8. Sonoda S, Saitoh E, Domen K, Chino N. Prognostication of stroke patients using the Stroke Impairment Assessment Set and the Functional Independence Measure. In: Chino N, Melvin JL, eds. Functional Evaluation of Stroke Patients. 1st ed. Tokyo: Springer-Verlag Tokyo; 1996. p. 103–14.
9. Tokunaga M, Ikeda Y, Inoue M, Kodama J, Sakamoto M, Nagatomo M, et al. Multiple regression analysis

stratified by age and FIM at admission. J Clin Rehabil 2015; 24: 828−34. Japanese.
10. Wada Y, Sonoda S, Okamoto S, Watanabe M, Okazaki H, Okuyama Y. Comparison of prediction accuracy of the total score of FIM motor items at discharge in post-stroke patients in a Kaifukuki rehabilitation ward. Jpn J Compr Rehabil Sci 2019; 10: 71−6.
11. Koh GCH, Chen CH, Petrellia R, Thind A. Rehabilitation impact indices and their independent predictors; a systematic review. BMJ Open 2013: 3(9): e003483.
12. Tokunaga M, Tokunaga A, Imada Y, Sannomiya K, Nojiri S, Watanabe S, et al. Deviation value of FIM gain. J Clin Rehabil 2017; 26: 97−103. Japanese.
13. Yanai H. Statcel, the useful addin forms on Excel, 4th ed. OMS publishing, 2016. p. 1−309. Japanese.
14. Tokunaga M, Sannomiya K, Nakanishi R, Yonemitsu H. The external validity of multiple regression analyses predicting discharge FIM score in patients with stroke hospitalized in Kaifukuki rehabilitation wards. Jpn J Compr Rehabil Sci 2015; 6: 14−20.
15. Tokunaga M, Tori K, Eguchi H, Kado Y, Ikejima Y, Ushijima M, et al. The stratification of motor FIM and cognitive FIM and the creation of four prediction formulas to enable higher prediction accuracy of multiple linear regression analysis with motor FIM gain as the objective variable. Jpn J Compr Rehabil Sci 2017; 8: 21−9.
16. Okamoto S, Sonoda S, Watanabe M, Okazaki H, Yagihashi K, Okuyama Y. Relationship between Functional Independence Measure (FIM) score on admission and influence of inhibitive factors in a comprehensive inpatient stroke rehabilitation ward. Jpn J Compr Rehabil Sci 2018; 9: 59−65.
17. Tokunaga M, Taniguchi M, Nakakado K, Mihono T, Okido A, Ushijima T, et al. Assessment of the effects of factors in stroke rehabilitation using eight multiple regression analyses. Jpn J Compr Rehabil Sci 2015; 6: 78−85.
18. Tokunaga M. Review of multiple regression analysis for stroke patients hospitalized in Kaifukuki rehabilitation wards. J Clin Rehabil (in press). Japanese.