Japanese Journal of Comprehensive Rehabilitation Science (2016)

Original Article

Relationship between improvement in GNRI, a nutritional index, and improvement in motor FIM in elderly stroke patients hospitalized in a *Kaifukuki* Rehabilitation Ward

Makoto Tokunaga, MD, PhD,[1] Ayumi Beppu,[2] Yasuki Tamura,[2] Kumiko Oowaki, MT,[3] Yoshimi Tokunaga, MT,[3] Chika Ishihara, RD,[4] Kiyomi Shibata, RD,[4] Kiyomi Tanaka, RD,[4] Masako Takayama, RD[4]

[1]Department of Rehabilitation, Kumamoto Kinoh Hospital, Kumamoto, Japan
[2]Department of Information Systems, Kumamoto Kinoh Hospital, Kumamoto, Japan
[3]Department of Clinical Investigation, Kumamoto Kinoh Hospital, Kumamoto, Japan
[4]Department of Nutrition and Food Service, Kumamoto Kinoh Hospital, Kumamoto, Japan

ABSTRACT

Tokunaga M, Beppu A, Tamura Y, Oowaki K, Tokunaga Y, Ishihara C, Shibata K, Tanaka K, Takayama M. Relationship between improvement in GNRI, a nutritional index, and improvement in motor FIM in elderly stroke patients hospitalized in a *Kaifukuki* Rehabilitation Ward. Jpn J Compr Rehabil Sci 2016; 7: 7−12.

Objective: To clarify the relationship between improvement in the Geriatric Nutritional Risk Index (GNRI) and improvement in the Functional Independence Measure (FIM).

Methods: The subjects were 155 patients aged 65 years or older selected among stroke patients admitted to a *Kaifukuki* Rehabilitation Ward. Seven items, including GNRI at hospital admission and degree of GNRI improvement, served as independent variables. For multiple regression analysis, motor FIM score at hospital discharge was the dependent variable. For multiple logistic regression analysis, motor FIM gain (1:13 points or more, 0:12 points or less) was the dependent variable.

Results: GNRI at admission was a significant positive independent variable in the multiple regression analysis. GNRI at admission and degree of GNRI improvement were both significant independent variables in the multiple logistic regression analysis, with odds ratios of 1.084 and 1.090, respectively.

Conclusion: Improvements in motor FIM are greater when GNRI at admission and the degree of GNRI improvement are larger.

Key words: Geriatric Nutritional Risk Index, FIM gain, stroke, multiple regression analysis, multiple logistic regression analysis.

Correspondence: Makoto Tokunaga, MD, PhD
Department of Rehabilitation, Kumamoto Kinoh Hospital, 6−8−1 Yamamuro, Kita-ku, Kumamoto 860−8518, Japan.
E-mail: tokunaga@juryo.or.jp
Accepted: March 8, 2016
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.

Introduction

Poor nutritional status in stroke patients is associated with increased severity of the disease, mortality, infection complications, swallowing difficulty, and less improvement in activities of daily living (ADL) [1−5]. However, few studies have examined how the improvements in nutritional status correlate with improvements in physical outcome and ADL [6,7]. Nii et al. [7] studied 67 patients with cerebrovascular disorders admitted to a *Kaifukuki* Rehabilitation Ward [8] whose body mass index (BMI) was 19 kg/m^2 or less or who had lost 2 kg or more since disease onset. They used the Geriatric Nutritional Risk Index (GNRI) [9] as an index of nutritional status, and Functional Independence Measure (FIM) [10] gain (discharge FIM score−admission FIM score) and FIM efficiency (FIM gain/days in hospital) as indices of ADL improvement. The 31 subjects whose GNRI improved in the hospital had significantly greater FIM gain and FIM efficiency than the 36 subjects whose GNRI did not improve. Multiple regression analysis with FIM efficiency as the dependent variable showed degree of GNRI improvement, energy intake at admission, and intracerebral hemorrhage to be the significant positive independent variables [7].

However, since this data was from a single institution, there is room for doubt that the results were due to that hospital's special characteristics. Thus, similar results from another institution are needed. Moreover, the multiple regression analysis performed by Nii et al. [7] was problematic because the number of subjects was less than the number necessary for the number of independent variables used.

The objective of the present study was to clarify how GNRI at admission and GNRI improvement relate to FIM improvement among stroke patients 65 years old and older admitted to a *Kaifukuki* Rehabilitation Ward.

Subjects and methods

This was a retrospective study. The subjects were selected from 1,424 stroke patients who were admitted to hospital A's *Kaifukuki* Rehabilitation Ward from September 1, 2010 to September 4, 2015, after being treated at acute phase hospitals. Based on the conditions shown in Figure 1, 155 patients were selected. Subarachnoid hemorrhage due to trauma was not included.

GNRI was calculated as [14.89×serum albumin (g/dL)]+[41.7×(current body weight / standard body weight)] [9]. If current weight was greater than standard weight, then 1 was used as the ratio of current to standard weight [9]. As in Nii et al.'s study [7], standard body weight was calculated as height (m)^2×22.

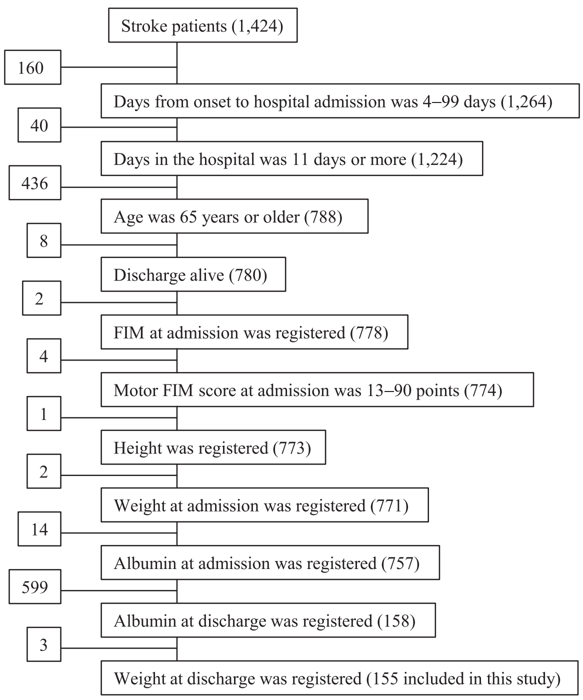

Figure 1. Inclusion and exclusion criteria.
FIM: Functional Independence Measure, Numerical value: number of patients.

Investigation 1: Comparison of GNRI improved group to GNRI non-improved group

The subjects were divided into 109 patients whose GNRI improved while in the *Kaifukuki* Rehabilitation Ward (GNRI improved group) and 46 patients whose GNRI did not change or decreased (GNRI non-improved group). Significant differences between the groups were examined with the Mann-Whitney *U* test and chi-square test of independence for the following items: age, sex, stroke type (cerebral infarction, cerebral hemorrhage, subarachnoid hemorrhage), days from onset to hospital admission, days in the hospital, total units of physical and occupational therapy (training units), nutritional method at admission (oral, tube, intravenous), nutritional method at discharge, energy intake at admission, energy intake at discharge, GNRI at admission, total score for 5 cognitive FIM items at admission (cognitive FIM), cognitive FIM gain, total score for 13 motor FIM items at admission (motor FIM), and motor FIM gain. Note that patients who used a combination of oral and tube feeding were classified as tube feeding. Training units were the number of units prescribed at admission (20 min of rehabilitation=1 unit).

Investigation 2: Multiple regression analysis with motor FIM score at discharge as the dependent variable

Multiple regression analysis was performed with motor FIM score at discharge as the dependent variable, and age, motor FIM score at admission, cognitive FIM score at admission, days in the hospital, GNRI at admission, degree of GNRI improvement while hospitalized, and number of training units as the independent variables.

Investigation 3: Multiple logistic regression analysis with motor FIM gain as the dependent variable

Multiple logistic regression analysis was performed with motor FIM gain as the dependent variable and the 7 items listed in investigation 2 as the independent variables. The median motor FIM gain was 13 points, so gains of 13 points or more were treated as 1 and gains of 12 points or less were treated as 0.

IBM SPSS Statistics version 23.0 was the statistical software used. The significance level was less than 5%.

This study was approved by hospital A's clinical research ethics committee. Information on this study, including its objectives, was posted inside the hospital and on its website. All personal information was converted to data so that individuals could not be identified.

Results

Table 1 shows the basic attributes of the 155 subjects. Median GNRI at admission was 84.9, the median degree of GNRI improvement was 4.1, and the median motor FIM gain was 13 points (Table 1).

GNRI at admission and motor FIM score at admission were significantly lower in the GNRI improved group compared with the GNRI non-improved group (Table 2). A significant difference between the groups was also observed for stroke type. Significant differences were not observed for age, sex, days from onset to admission, days in the hospital, training units, nutritional method at admission and discharge, energy intake at admission and discharge, cognitive FIM score at admission, or cognitive FIM gain. Motor FIM gain was higher in the GNRI improved group (median 15 points) than in the GNRI non-improved group (median 10 points), but the difference was not significant (p=0.25).

In the multiple regression analysis, there were no correlations between independent variables of 0.8 or higher (no multicollinearity) and a significant prediction formula was obtained ($p<0.001$). However, the residual error did not have a normal distribution (Shapiro-Wilk test). The coefficient of determination (R^2), which indicates how well the independent variables explain the dependent variable, was 0.755 (Table 3). Motor FIM score at admission, cognitive FIM score at admission, days in the hospital, age, and GNRI at admission were significant independent variables, but degree of GNRI improvement (p=0.071) and training units (p=0.62) were not. The partial regression coefficient (B) was positive for motor FIM score at admission, cognitive FIM score at admission, days in the hospital, age, GNRI at admission, and degree of GNRI improvement (when these are higher, motor FIM score at discharge is higher), and was negative for age (greater age means lower motor FIM score at discharge). The standard partial regression coefficient (β), which indicates the relative strength of the independent variables over the dependent variable, was largest for motor FIM score at admission, followed in order by cognitive FIM score at admission, days in the hospital, age, GNRI at admission, and degree of GNRI improvement.

In the multiple logistic regression analysis, cognitive FIM score at admission, days in the hospital, GNRI at admission, and degree of GNRI improvement were significant independent variables, with odds ratios of 1.151, 1.034, 1.081, and 1.089, respectively (Table 4).

Table 1. Basic attributes of the 155 subjects.

Stroke type	Infarction 65, hemorrhage 45, SAH 45
Age	78.3±7.3 (78)
Sex	Male 61, female 94
Days from onset to hospital admission	24.3±15.4 (21)
Days in the hospital	87.1±34.2 (89)
Total units of physical therapy	2.5±0.6 (3)
Total units of occupational therapy	2.4±0.7 (3)
Total units of speech-language-hearing therapy	1.9±0.9 (2)
Height	154.9±8.5 (155)
Weight at admission	48.2±8.5 (47.8)
Weight at discharge	47.1±7.9 (46.4)
Nutritional method at admission	Oral 91, tube 63, intravenous 1
Nutritional method at discharge	Oral 110, tube 45, intravenous 0
Energy intake at admission	1,339±287 (1,400)
Energy intake at discharge	1,467±304 (1,570)
Albumin at admission	3.2±0.4 (3.2)
Albumin at discharge	3.5±0.5 (3.5)
GNRI at admission	84.5±6.9 (84.9)
GNRI at discharge	87.8±6.8 (89.2)
GNRI improvement	3.2±6.7 (4.1)
Cognitive FIM score at admission	15.8±8.8 (14)
Cognitive FIM score at discharge	19.4±9.3 (20)
Cognitive FIM gain	3.6±5.1 (3)
Motor FIM score at admission	30.7±21.3 (20)
Motor FIM score at discharge	46.2±27.5 (43)
Motor FIM gain	15.5±16.1 (13)

Numerical value, mean±standard deviation or number of patients; FIM, Functional Independence Measure; GNRI, Geriatric Nutritional Risk Index; Total units of therapy, 1 unit is 20 min of rehabilitation; SAH, Subarachnoid hemorrhage.

Table 2. Comparison of GNRI improved group to GNRI non-improved group.

	GNRI improved group	GNRI non-improved group	Significance
Number of patients	109	46	—
Age	78.5±6.85 (78)	78.0±8.5 (79.5)	0.70
Sex	Male 42, female 67	Male 19, female 27	0.74
Stroke type	Infarction 49, hemorrhage 36, SAH 24	Infarction 16, hemorrhage 9, SAH 21	<0.05
Days from onset to hospital admission	23.9±15.5 (21)	25.3±15.4 (22.5)	0.60
Days in the hospital	89.9±31.7 (93)	80.3±39.1 (78)	0.11
Total units of physical and occupational therapy	5.0±1.1 (5)	5.0±1.1 (5)	0.94
Nutritional method at admission	Oral 62, tube 47, intravenous 0	Oral 29, tube 16, intravenous 1	0.21
Nutritional method at discharge	Oral 75, tube 34, intravenous 0	Oral 35, tube 11, intravenous 0	0.16
Energy intake at admission	1,337±277 (1,400)	1,344±311 (1,400)	0.67
Energy intake at discharge	1,457±304 (1,500)	1,491±307 (1,600)	0.33
GNRI at admission	82.6±6.0 (83.5)	89.1±6.9 (88.0)	<0.001
GNRI improvement	6.6±4.4 (5.8)	−4.7±3.9 (−4.0)	—
Cognitive FIM score at admission	15.0±8.5 (13)	17.7±9.1 (14.5)	0.08
Cognitive FIM gain	3.6±5.1 (2)	3.7±5.3 (3)	0.85
Motor FIM score at admission	28.0±18.3 (18)	37.2±26.2 (25.5)	<0.05
Motor FIM gain	16.5±16.5 (15)	13.3±15.0 (10)	0.25

Significance: Sex, disease type, and nutritional method were examined with the chi-square test of independence. The Mann-Whitney *U* test was used for all others. (p<0.05 was considered significant).
—: Significant difference not examined. Training units: Total number of physical and occupational therapy units.
Numerical values: Sex, disease type, and nutritional method were expressed in number of patients. All others were expressed as mean±standard deviation (median).

Table 3. Multiple regression analysis.

	Coeff (B)	95% CI of B		Std Coeff (β)	Significance (p)
		Lower	Upper		
Motor FIM score at admission	0.834	0.660	1.008	0.647	<0.001
Cognitive FIM score at admission	0.772	0.402	1.142	0.246	<0.001
Days in the hospital	0.134	0.059	0.209	0.167	<0.01
Age	−0.472	−0.861	−0.143	−0.125	<0.01
GNRI at admission	0.478	0.050	0.907	0.120	<0.05
GNRI improvement	0.361	−0.032	0.753	0.088	0.071
Total units of physical and occupational therapy	−0.515	−2.582	1.553	−0.021	0.623

Constants, −5.280; regression equation p values, <0.001; coefficient of determination (R^2), 0.755; dependent variable, motor FIM at discharge; Absolute values for standard partial regression coefficients (β) of the dependent variables were ordered by size.
Coeff, Coefficient; Std Coeff, Standard coefficient; CI, Confidence interval.

Table 4. Multiple logistic regression analysis.

	Coeff (B)	OR	95% CI of OR	Significance (p)
Motor FIM score at admission	−0.011	0.989	0.959−1.020	0.468
Cognitive FIM score at admission	0.141	1.151	1.070−1.240	<0.001
Days in the hospital	0.033	1.034	1.017−1.051	<0.001
Age	−0.048	0.953	0.901−1.009	0.100
GNRI at admission	0.078	1.081	1.004−1.164	<0.05
GNRI improvement	0.086	1.089	1.016−1.169	<0.05
Total units of physical and occupational therapy	0.102	1.107	0.772−1.588	0.579

Model chi-square test, p<0.001; discrimination accuracy rate, 75.5%; dependent variable, motor FIM gain (0:12 or less, 1:13 or more).
Coeff, Coefficient; OR, odds ratio; CI, Confidence interval.

Discussion

Nii et al. [7] performed stepwise multiple regression analysis with FIM efficiency as the dependent variable and 9 independent variables: age, sex, stroke type, albumin level at admission, BMI, GNRI at admission, FIM score at admission, energy intake at admission, and degree of GNRI improvement. Although 6 items, including GNRI at admission, were not significant, they reported that degree of GNRI improvement, energy intake at admission, and intracerebral hemorrhage were significant positive variables. As Nii et al. [7] stated in their article, there have been few reports on how improvement in the nutritional status of stroke patients relates to improvements in physical outcome and ADL. The only such report that Nii et al. [7] referred to is one by Ha et al. [6] In that study, 58 acute stroke patients were placed in an individualized nutrition group and 66 such patients were placed in a regular nutrition group. Three months later, the proportions of patients whose body weight had decreased by 5% or more, quality of life (QOL), grip strength, and days in the hospital were compared. The proportion of patients whose body weight had decreased by 5% or more was significantly smaller in the individualized nutrition group, while QOL and grip strength were significantly larger in this group [6].

In the present study, significant differences between the GNRI improved group and GNRI non-improved group were observed for GNRI at admission and motor FIM score at admission. As this means that simple comparisons of motor FIM gain were impossible, we thought multivariate analysis was necessary. Multiple regression analysis similar to that performed by Nii et al. [7] showed that motor FIM score at discharge was influenced by motor FIM score at admission, cognitive FIM score at admission, days in the hospital, and age. Even when these factors are taken into account, motor FIM score at discharge was significantly higher when GNRI at admission was larger. However, the degree of GNRI improvement was not significant (p=0.071). The multiple regression analysis used a parametric method but the residual error did not have a normal distribution. Thus, we performed a multiple logistic regression analysis, which does not require as much strictness in terms of data types or distributions. Using motor FIM gain (0: 2 points or less, 1:13 points or more) as the dependent variable, both GNRI at admission and degree of GNRI improvement were significant independent variables, with odds ratios of 1.081 and 1.089, respectively (motor FIM gain is more likely to be 13 points or more with higher GNRI at admission or greater GNRI improvement).

The results of the present study confirm the conclusion of Nii et al. [7] that FIM efficiency is greater in stroke patients admitted to a *Kaifukuki* Rehabilitation Ward with greater degree of GNRI improvement.

However, our study differs from that of Nii et al. [7] in several respects. First, the numbers of independent variables and patients differed. Nii et al. [7] used 9 independent variables and 67 patients. However, the number of patients in a multiple regression analysis needs to be 15 times the number of independent variables [11], which means that Nii et al. [7] should have used at least 135 patients (9×15). In contrast, the present study used 7 independent variables and 155 patients, which is more than the number required. Second, the 67 patients in Nii et al.'s report [7] included 39 cases of cerebral infarction, 16 cases of cerebral hemorrhage, 8 cases of subarachnoid hemorrhage, and 4 cases of subdural hematoma. In contrast, the present study was limited to stroke patients (cerebral infarction, cerebral hemorrhage, subarachnoid hemorrhage) and did not include subdural hematoma. Third, Nii et al. [7] did not describe multicollinearity, coefficients of determination (R^2), or residual error normality. They used albumin at admission and BMI, which are thought to be tied to GNRI at admission, as independent variables, but did not discuss the presence or absence of multicollinearity. In a review of multiple regression analyses [12], 33 reports that used FIM score at discharge as the dependent variable had a mean R^2 of 0.65 (0.35−0.82) and 20 reports that used FIM gain had a mean R^2 of 0.22 (0.08−0.4), while 3 reports that used FIM efficiency had a low mean R^2 of 0.08 (0.03−0.14). It would be interesting to know the R^2 value in Nii et al.'s study [7], which used FIM efficiency as the dependent variable, but it was not provided, and neither did they describe residual error normality. Fourth, GNRI at admission was a significant independent variable in our study but not in theirs. Yet, many studies have found links between undernutrition and a low degree of ADL improvement [1−5]; a correlation between GNRI at admission and a low degree of ADL improvement has also been reported [13].

Meyer et al. [12] reviewed 63 prediction formulas from 27 studies that used multiple regression analysis to predict the functional outcome of acute stroke patients. Of 126 factors used in the multiple regression analyses, 63 were significant independent variables [12]. Of these, the following 8 factors were used in at least 5 formulas and were a significant factor in at least half of them: FIM at admission (significant in 46 of 51 formulas), age (30/45), previous stroke (5/10), Barthel index at admission (6/6), neglect (4/6), dysphasia (4/6), impulsivity (4/6), and the National Institute of Health Stroke Scale (5/5) [12]. There was a mean of 4.1 (standard deviation 2.5) significant independent variables in each formula [12]. The only nutrition-related indices were serum albumin level in 2 formulas and BMI in 1 formula [12]. Training time was not used in any of the 63 formulas, nor was GNRI [12]. As the impact of GNRI at admission and degree of GNRI improvement on FIM improvement in elderly recovery-stage stroke patients has now been clarified, we think including these factors in future multiple regression analyses and multiple logistic regression analyses should be considered. However, since the standard partial regression coefficient (β) decreased in size from motor FIM score at admission, cognitive FIM score at admission, days in the hospital, age, GNRI at admission, to degree of GNRI improvement, the β values of GNRI at admission and degree of GNRI improvement should be compared to the β values of a variety of other factors.

This study had several limitations. First, the appropriateness of the independent variables used could be questioned. Meyer et al.'s review [12] was of multiple regression analyses on acute-stage stroke patients. We do not yet have a set of independent variables that is optimal for recovery-stage stroke patients. Thus in the present study, we chose independent variables based on the literature and medical considerations. Second, we could not declare a causal relationship in which greater GNRI improvement means greater motor FIM gain. Third, we did not survey the number or severity of comorbidities. We cannot deny the possibility that patients with little GNRI improvement had severe comorbidities, which led to small motor FIM gain (comorbidity as a confounding factor). Fourth is the fact that certified nutritionists intervene in patients with undernutrition. If nutritionists did not intervene, it would be correct to determine that undernutrition has a negative effect on FIM gain. However, it may also be correct to say that if these interventions are effective, undernutrition would have less of an impact on FIM gain. Fifth, the number of subjects was problematic; if there had been more subjects, degree of GNRI improvement may have also been significant in the multiple regression analysis. Sixth, some kind of bias may have arisen in the subject population when it was screened from 1,424 to 155 cases. Patients whose albumin levels were measured at discharge may have included a large number with low GNRI at admission or with little GNRI improvement. If so, the results would be biased toward undernutrition patients.

Going forward, a prospective all-case study that takes comorbidities and nutritionist interventions into consideration should be performed.

References

1. Gariballa SE, Parker SG, Taub N, Castleden CM. Influence of nutritional status on clinical outcome after acute stroke. Am J Clin Nutr 1998; 68: 275−81.
2. The FOOD Trial Collaboration. Poor nutritional status on admission predicts poor outcomes after stroke, observational data from the FOOD trial. Stroke 2003; 34: 1450−6.
3. Davis JP, Wong AA, Schluter PJ, Henderson RD, O'Sullivan JD, Read SJ. Impact of premorbid undernutrition on outcome in stroke patients. Stroke 2004; 35: 1930−4.
4. Yoo SH, Kim JS, Kwon SU, Yun SC, Koh JY, Kang DW. Undernutrition as a predictor of poor clinical outcomes in acute ischemic stroke patients. Arch Neurol 2008; 65: 39−43.
5. Foley NC, Martin RE, Salter KL, Teasell RW. A review of the relationship between dysphagia and malnutrition following stroke. J Rehabil Med 2009; 41: 707−13.
6. Ha L, Hauge T, Spenning AB, Iversen PO. Individual, nutritional support prevents undernutrition, increases muscle strength and improves QoL among elderly at nutritional risk hospitalized for acute stroke, a randomized, controlled trial. Clin Nutr 2010; 29: 567−73.
7. Nii M, Maeda K, Wakabayashi H, Nishioka S, Tanaka A. Nutritional improvement and energy intake are associated with functional recovery in patients after cerebrovascular disorders. J Stroke Cerebrovasc Dis 2016; 25: 57−62.
8. Miyai I, Sonoda S, Nagai S, Takayama Y, Inoue Y, Kakehi A, et al. Results of new policies for inpatient rehabilitation coverage in Japan. Neurorehabil Neural Repair 2011; 25: 540−7.
9. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr 2005; 82: 777−83.
10. Data management service of the Uniform Data System for Medical Rehabilitation and the Center for Functional Assessment Research (1990) Guide for use of the uniform data set for medical rehabilitation. version 3.0, State University of New York at Buffalo, Buffalo.
11. Shintani A. Medical statistics. Tokyo: Igaku-shoin; 2015. p. 1−167. Japanese.
12. 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.
13. Nishioka S, Takayama M, Watanabe M, Urushihara M, Kiriya Y, Hijioka S. Prevalence of malnutrition in convalescent rehabilitation wards in Japan and correlation of malnutrition with ADL and discharge outcome in elderly stroke patients. Nihon Jomyaku Keicho Eiyo Gakkai Zashi 2015; 30: 1145−51. Japanese.