BRIEF REPORTS

Cutoff Value for a Nutritional Indicator Related to Gait Independence in Elderly Fracture Patients: A Preliminary Study

Megumi Kurita, RPT¹, Takaaki Fujita, Ph.D, OTR², Ryuichi Kasahara, MS, RPT¹, Yoko Ohira, Ph.D, MD¹, Koji Otsuki, Ph.D, MD¹ and Yuichi Yamamoto, RPT¹

¹) Department of Rehabilitation, Kita-Fukushima Medical Center, Japan
²) Department of Occupational Therapy, School of Health Sciences, Fukushima Medical University, Japan

ABSTRACT. Objective: Previous studies have reported the relationship between nutritional status and gait independence in elderly fracture patients. However, the degree to which nutritional indicators are related to gait independence is unclear. The purpose of this study is to calculate a cutoff value for a nutritional indicator related to gait independence in patients with hip and vertebral compression fractures. Method: This study included 69 patients (33 hip fracture, 36 vertebral compression fracture) who underwent rehabilitation at a convalescent rehabilitation ward. The relationships between nutritional indexes (Mini-Nutritional Assessment-Short Form [MNA-SF] and skeletal muscle mass index [SMI]) at admission and gait independence at discharge were analyzed using logistic regression. In addition, receiver operating characteristic analysis was performed to calculate a cutoff value that predicts gait independence. Results: Among the nutritional indicators used in this study, only MNA-SF was significantly able to predict gait independence at discharge, and this association was maintained, even after adjustment for confounders. The calculated MNA-SF cutoff values were 5.5 (sensitivity 100%, specificity 46.3%) and 7.5 points (sensitivity 67.9%, specificity 78.0%). Conclusion: This study suggests that MNA-SF may be an index for predicting gait independence in patients with hip or vertebral compression fractures in the convalescent rehabilitation ward. The cutoff values calculated in this study were simple and useful index for physical therapists to interpret the results of MNA-SF. Key words: Nutrition, Gait, Cutoff

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Hip fractures and vertebral compression fractures are common in the elderly population. Japan’s aging population is the largest in the world and, in 2017, there were an estimated 193,400 hip fracture patients¹¹; vertebral fractures—reported to be >10 times more frequent than femoral fractures—have been estimated at 1-1.5 million per year². After such fractures, patients often present with gait disturbance and receive physical therapy aimed at improving their gait ability.

In order to perform effective physical therapy, it is important to understand the factors related to gait ability and to predict the prognosis accordingly. In recent years, the relationship between nutritional status and the effect of rehabilitation has gained attention. For example, previous studies reported that nutritional states were related to functional outcomes in elderly patients¹³ and those with various diseases, such as stroke⁸, Parkinson’s disease⁹, distal radius fracture¹⁰, and pneumonia¹¹. Similarly, it has been reported that nutritional status is associated with improvement in activities of daily living (ADL) and gait ability in patients with hip and vertebral compression fractures¹². Although there are some reports that nutritional interventions have not had significant impacts on long-term outcomes after hip fractures¹³,¹⁴, other studies have shown that nutritional inter-
ventions are effective for improving ADL and gait ability in patients with hip fractures.

These findings suggest that it is important for physical therapists to understand nutritional status, in order to consider intervention plans and predict prognosis when treating patients with hip and vertebral compression fractures. However, previous studies have not established the degree to which nutritional indicators relate to gait independence, i.e., cutoff values; it is difficult to interpret the results of nutritional assessments. Therefore, the purpose of this study is to calculate the cutoff value of a nutritional indicator related to gait independence in patients with hip and vertebral compression fractures. The findings of this study can provide a reference for interpreting nutritional indicators when predicting the prognosis of gait independence.

Method

Study design and patients

This study was a retrospective observational study including 69 patients (33 hip fracture, 36 vertebral compression fracture) who underwent rehabilitation at a convalescent rehabilitation ward between August 2018 and July 2020. The inclusion criteria were for patients aged >65 years, evaluated as not independent in gait at the time of their admission. Those with missing data, who transferred to another hospital, or who died were excluded. The Research Ethics Committees of Fukushima Medical University and Kita- Fukushima Medical Center reviewed and approved the study (No 94, general 2020-236), which was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Assessments

In order to examine the relationship between nutritional status at admission and gait independence at discharge, Mini-Nutritional Assessment-Short Form (MNA™-SF) and skeletal muscle mass index (SMI) were used as indicators of nutritional status. MNA™-SF is a shortened version of the Mini-Nutritional Assessment, a nutritional screening tool for the elderly. MNA™-SF is based on six items: decrease in food intake over the past 3 months, weight loss during the last 3 months, mobility, psychological stress or acute disease in the past 3 months, neuropsychological problems, and body mass index or calf circumference. In its original use, MNA™-SF scores of 12-14 points are judged as “normal nutritional status,” scores of 8-11 points are judged as “at risk of malnutrition,” and scores of 0-7 points are judged as “malnourished.” However, for this study’s purpose, MNA™-SF scores were treated as continuous variables. The patients included in this study inevitably scored 0 points for the items of “mobility” and “psychological stress or acute disease in the past 3 months.” SMI was measured using a body composition analyzer (InBody S10, InBody Japan, Tokyo, Japan). Gait independence at discharge was determined using the Functional independence measure (Locomotion: Walk), with ≥6 points being independent and ≤5 points being non-independent. In addition, we collected data on age, cognitive function, and knee extension strength, which were considered as confounding factors and have been reported to be associated with gait independence in previous studies. The revised Hasegawa’s Dementia Scale (HDS-R) was used as an indicator of cognitive function. The knee extension strength was measured using a hand-held dynamometer (μTas F1, Anima Co., Tokyo, Japan) in the sitting position, and the index in Nm/kg was calculated based on body weight and lower-limb length. MNA™-SF, HDS-R, and knee extension strength were assessed by physical therapists or occupational therapists within two weeks after admission to the convalescent rehabilitation ward. Other subject attributes at admission were obtained from medical records, including: gender, period from onset to admission, and intervention period.

Statistical analysis

Comparisons of nutritional status and other variables were performed between the two groups of patients, who were gait-independent at discharge (independent) or not (non-independent), using the t-test, Mann-Whitney test, and chi-square test. Next, in order to determine a nutritional index suitable for calculating a cutoff value, forced input method logistic regression analysis was performed using group (independent or non-independent) as a dependent variable, and MNA™-SF and SMI as independent variables (crude model). We also created a model in which age, HDS-R, knee extension strength, and fracture site (hip or vertebral) were used as adjustment variables (adjusted model). When the correlation coefficient among the independent and adjustment variables was 0.7 or higher, two variables with high correlation coefficient were input into the model separately to avoid multicollinearity.

For nutritional indicators that were significantly associated by logistic regression analysis with gait independence at discharge, receiver operating characteristic (ROC) analysis was used to calculate a cutoff value for distinguishing gait independence. The area under the ROC curve (AUC) was calculated with gait independence at discharge as the dependent variable and nutrition index as the independent variable. When the AUC was ≥0.7 (moderate accuracy), a cutoff value was calculated using Youden’s index. The level of significance was set at 5% for all tests, and all analyses were performed using SPSS Statistics version 25 (IBM, Armonk, NY, USA).

Results

Table 1 shows the subjects’ attributes and nutritional
Table 1. Attributes, nutritional status, and gait capacity of the subjects

|                          | Overall (n = 69) | Independent (n = 28) | Non-independent (n = 41) | p value |
|--------------------------|------------------|----------------------|--------------------------|---------|
| Age (years)              | 83.4 ± 7.8       | 80.0 ± 7.2           | 85.7 ± 7.4               | <0.01   |
| Gender (Men, %)          | 23.2             | 17.9                 | 26.8                     | 0.39    |
| Bone fracture site (n)   |                  |                      |                          |         |
| Femur                   | 33               | Femur 8              | Femur 25                 | <0.01   |
| Vertebral               | 36               | Vertebral 20         | Vertebral 16             |         |
| Period from onset to admission (days) | 20.6 ± 10.2 | 18.0 ± 7.7 | 22.3 ± 11.4               | 0.08    |
| Intervention period (days) | 57.9 ± 18.2 | 56.0 ± 19.9 | 59.1 ± 17.1               | 0.49    |
| Knee extension strength (Nm/kg) |              |                      |                          |         |
| Stronger side            | 0.72 ± 0.3       | 0.82 ± 0.3           | 0.65 ± 0.3               | <0.01   |
| Weaker side              | 0.55 ± 0.3       | 0.65 ± 0.3           | 0.48 ± 0.2               | <0.01   |
| HDS-R (points)          | 20.0 ± 6.6       | 22.9 ± 5.0           | 18.0 ± 6.8               | <0.01   |
| MNA®-SF (points)        | 6.7 ± 2.0        | 8.0 ± 1.6            | 5.8 ± 1.8                | <0.01   |
| SMI (kg/m²)             | 4.9 ± 1.0        | 5.3 ± 1.1            | 4.6 ± 0.8                | <0.01   |

Mean ± Standard deviation

Abbreviation: HDS-R, revised Hasegawa’s Dementia Scale; MNA®-SF, Mini Nutritional Assessment-Short Form; SMI, Skeletal Muscle Mass Index

Table 2. Logistic regression analysis of gait independence at discharge and nutritional indicators at admission

|                          | Crude model | Adjusted model |
|--------------------------|-------------|----------------|
|                          | OR (95% CI) | p              | OR (95% CI) | p  |
| MNA®-SF                  | 1.96 (1.36, 2.87) | <0.01 | 2.39 (1.43, 4.02) | <0.01 | 2.27 (1.39, 3.71) | <0.01 |
| SMI                      | 1.51 (0.78, 2.94) | 0.22 | 1.01 (0.42, 2.43) | 0.98 | 1.12 (0.48, 2.62) | 0.79 |
| Moderators               |             |                |              |      |
| Age                      | 0.91 (0.82, 1.01) | 0.07 | 0.91 (0.82, 1.01) | 0.07 |
| HDS-R                    | 1.04 (0.91, 1.19) | 0.53 | 1.05 (0.92, 1.19) | 0.51 |
| Bone fracture site       | 5.29 (1.15, 24.28) | 0.03 | 4.24 (0.89, 20.14) | 0.07 |
| Knee extension strength  | 17.21 (0.65, 454.93) | 0.09 | 7.07 (0.36, 140.15) | 0.20 |

Abbreviation: MNA®-SF, Mini Nutritional Assessment-Short Form; SMI, Skeletal Muscle Mass Index; HDS-R, revised Hasegawa’s Dementia Scale

status. There were 28 (40.6%) patients in the independent group and 41 (59.4%) in the non-independent group. Comparisons between the independent group and non-independent group found significant differences for all items except gender, period from onset to admission, and intervention period (Table 1). In logistic regression analysis of crude model, the nutrition indicator MNA®-SF was able to significantly predict gait independence at discharge (OR: 1.96; 95% confidence interval: 1.4-2.9; P < 0.01) (Table 2). In the adjusted model, knee extension strength on the stronger and weaker side was input into the model separately because the correlation coefficient was ≥0.7. MNA®-SF was significantly associated with gait independence at discharge in both the adjusted models (with age, fracture site, HDS-R, and knee extension strength on the stronger or weaker side as adjustment variables). In the ROC analysis, the AUC of MNA®-SF was 0.81, and the cutoff values based on a high Youden’s index were 5.5 (sensitivity 100%, specificity 46.3%, Youden’s index 0.463) and 7.5 points (sensitivity 67.9%, specificity 78.0%, Youden’s index 0.459) when gait independence was set to “positive”.

Discussion

This study used MNA®-SF and SMI as indicators of nutritional status; only MNA®-SF was associated with gait
independence at discharge. Since this association was maintained even after adjustment for fracture site in the multivariate analysis, it is considered that MNA\textsuperscript{8}-SF and gait independence are related, regardless of whether the patient had a hip fracture or vertebral compression fracture. A previous study has already reported an association between MNA\textsuperscript{8}-SF and gait ability in patients with hip fractures\textsuperscript{19}; the results of our study coincide.

Few other previous studies have compared multiple nutritional indicators as predictors of outcomes in patients with fractures. Helminen et al.\textsuperscript{20} compared MNA\textsuperscript{8} and serum albumin as predictors of outcomes in patients with hip fractures, and reported that MNA\textsuperscript{8} (long-form) and MNA\textsuperscript{8}-SF were useful for predicting mobility and living environment. Their finding suggested that MNA\textsuperscript{8}-SF may be a better index for predicting gait independence in patients with fracture.

In previous studies that have used MNA\textsuperscript{8}-SF, the original cutoff values of the index were used to classify subjects (12-14 points, “normal nutritional status”; 8-11 points, “at risk of malnutrition”; and 0-7 points, “malnourished”). Our study has taken an original approach by treating nutritional indexes as continuous variables, attempting to calculate a more accurate and reliable cutoff value relating to prognosis of gait independence in fracture patients. The cutoff values calculated in this study were 5.5 and 7.5 points in MNA\textsuperscript{8}-SF. We believe that 7.5 points is a reasonable cutoff value because of the balance between sensitivity and specificity. In other words, when the MNA\textsuperscript{8}-SF score at admission is 7 points or less, gait independence at discharge may be difficult. The cutoff value (7.5 points) calculated in this study was consistent with the original MNA\textsuperscript{8}-SF range for “malnourished.” Prior to this study, the degree of nutritional status that affected gait independence was unknown. For example, it was unclear within which range of MNA\textsuperscript{8}-SF gait independence would be affected. As a result of this study, it was clarified for the first time that MNA\textsuperscript{8}-SF is related to the gait independence of patients with fractures, regardless of whether or not it corresponds to the original MNA\textsuperscript{8}-SF range for “malnutrition,” i. e., 0-7 points.

However, it should be noted that some items of MNA\textsuperscript{8}-SF become 0 points in patients with fractures, such as those included in this study. This indicates that it is important that the total score of “decrease in food intake over the past 3 months,” “weight loss during the last 3 months,” “neuropsychological problems,” and “body mass index or calf circumference” reaches 8 points for gait independence in patients with fractures.

Since our cutoff value (7.5 points in MNA\textsuperscript{8}-SF) had sensitivity of 67.9% and specificity of 78.0%, it may be clinically realistic to use it in combination with other variables for predicting prognosis. However, our cutoff value may be a simple and useful index for physical therapists to interpret the results of MNA\textsuperscript{8}-SF.

On the other hand, the odds ratio in the logistic regression analysis revealed that the bone fracture site had a very strong effect on gait independence. A previous study reported that 40%-60% patients with hip fractures regained their prefracture level of mobility within 1 year\textsuperscript{21}. To the best of our knowledge, there are no large-scale studies investigating the rate of regaining gait independence in patients with vertebral fractures. However, patients with vertebral fractures are more likely to recovery gait independence than patients with hip fractures in general. Considering that the association between MNA\textsuperscript{8}-SF and gait independence was maintained even after adjustment for fracture site in the logistic regression analysis, MNA\textsuperscript{8}-SF and gait independence can be considered to be associated, regardless of whether the patient has a hip fracture or a vertebral fracture. However, considering the magnitude of the impact of the fracture site on gait independence, it cannot be denied that the factors related to gait independence may differ between patients with hip fractures and those with vertebral fractures. In other words, the degree of influence of MNA\textsuperscript{8}-SF on gait independence may be different in patients with hip fractures and in those with vertebral fractures.

One limitation of this study is that it contained only a small sample. Therefore, not all potential confounders, including pain and operative procedures, which are critical factors, could be included in multiple logistic analysis. Also due to the small sample size, it was difficult to perform detailed analysis, such as calculating the respective influence of MNA\textsuperscript{8}-SF for hip and vertebral compression fractures. Therefore, this study is only a preliminary study, in future it will be necessary to increase the sample size and perform more detailed analysis.

**Conclusion**

MNA\textsuperscript{8}-SF score at admission to a convalescent rehabilitation ward is associated with gait independence at discharge in patients with hip and vertebral compression fractures. The MNA\textsuperscript{8}-SF cutoff value associated with gait independence is 7.5 points.

**Conflict of Interest:** The authors declare no conflicts of interest associated with this manuscript.

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