



Original Article

Relationship between the independence level of individual motor-related functional independence measure items and its total score in patients after hip fracture: an ordinal logistic modelling study

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Abstract. [Purpose] The independence level of activities of daily living during the recovery period should be predicted to plan a rehabilitation program. This study aimed to assess the relationship between the independence levels of individual motor-related Functional Independence Measure (FIM-motor) items and total FIM-motor score in patients after hip fracture. [Participants and Methods] This study retrospectively analyzed 40 patients who had stayed in a convalescent rehabilitation hospital after hip fracture. The FIM-motor score was assessed for each patient on admission, after 2 and 4 weeks of hospitalization, and at discharge. [Results] The median FIM-motor scores were 52.5 on admission and 83.0 at discharge. The results of ordinal logistic modeling were statistically significant for all 13 FIM-motor items. The independence levels for transfer to toilet and bed/chair/wheelchair were proportionally distributed across the entire range of total FIM-motor scores. However, a weak relationship was observed between the scores for bladder and bowel management and total FIM-motor scores. Although eating and grooming were relatively easy items, stair-climbing and locomotion were difficult. [Conclusion] The relationship between the independence level of individual FIM-motor items and the total FIM-motor score varied widely. This knowledge might be useful while scheduling rehabilitative treatments for patients after hip fracture.

Key words: Outcome, Orthopedics, Prognosis

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INTRODUCTION

Bone fracture is an event that may impair independence in activities of daily living (ADL) and increase the care burden in the elderly population¹⁾. Hip fracture is the most common type of fracture in the elderly²⁾. The primary treatment for hip fracture is surgery. However, patients may be limited in many aspects of ADL after surgery, including sitting, walking, toileting, dressing the lower body, and bathing. These patients often need rehabilitation to recover their independence in ADL.

The motor-related component of the Functional Independence Measure (FIM-motor) is an ADL assessment tool³⁾ that is widely used in patients undergoing rehabilitation for various conditions, including stroke, traumatic brain injury, spinal cord injury, and orthopedic disorders, as well as in the community-dwelling elderly population³⁻⁹⁾. It is well known that some

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FIM-motor items such as eating and grooming are easy to perform, whereas others such as stair climbing are difficult. Such knowledge is useful when scheduling the main targets of rehabilitative treatment during the recovery period. If the independence level of each FIM-motor item can be predicted by total FIM-motor score, it may be possible to plan a rehabilitation program more efficiently. However, few studies have focused on the psychometrics of FIM-motor items in patients after hip fracture¹⁰. The aim of this study was to determine the relationship between the independence level of individual FIM-motor items and total FIM-motor score in patients after hip fracture.

PARTICIPANTS AND METHODS

We retrospectively sampled patients who were admitted to our affiliated convalescent rehabilitation hospital (Nishinomiya Kyoritsu Rehabilitation Hospital) after hip fracture between September 2018 and December 2020. The study protocol was approved by the Hyogo College of Medicine Ethics Committee (No. 3788). Informed consent was obtained from all individual participants included in this study by an opt-out method. To minimize variability arising from differences in the treatment protocol during acute care, we limited the study population to patients who were treated in the same acute care facility. Typically, these patients were admitted to the acute care hospital soon after the occurrence of hip fracture. The diagnosis was confirmed by radiographic examination, and surgery was performed within 2 days of onset. Bipolar hip arthroplasty was indicated for the majority of patients with an intracapsular fracture, a compression hip screw was occasionally placed for patients with a non-displaced intracapsular fracture, and a gamma nail was applied in those with an extracapsular fracture. After surgery, the patients received a combined daily total of up to 180 min of rehabilitative treatment during hospitalization, including physical therapy and occupational therapy.

Patients' data, including age, gender, type of hip fracture, entire length of hospital stay (for acute care and rehabilitation), comorbidities, past medical history, and pre-hospitalization health status, including motor and cognitive aspects of ADL, were collected from the medical records. The inclusion criteria were as follows: (1) first-ever hip fracture, (2) ability to walk independently without a cane before injury, (3) no evidence of dementia¹¹, (4) no functional deficit in the upper or lower extremities^{12, 13}, and (5) no severe comorbidity that could limit rehabilitative treatment (e.g., renal failure requiring dialysis)¹⁴. Patients with additional fractures at sites other than the hip (e.g., a radial fracture) were excluded², as were those who subsequently required acute treatment for medical conditions such as stroke, angina pectoris, or other concomitant conditions. Patients whose convalescent rehabilitation hospital stay was less than 1 month were also excluded because of the methodology for collecting the FIM-motor data (see next section).

Initially, 51 patients were enrolled. After excluding two patients who sustained an upper extremity fracture in addition to their hip fracture, three who required acute medical services (one each for gallstones, gastrointestinal bleeding, and ischemic stroke), and six whose stay in the convalescent rehabilitation hospital was less than 1 month, data for 40 patients were available for analysis. Median age was 81.5 years, and 29 patients (72.5%) were female.

The FIM-motor score is frequently used to assess the ability to perform ADL in patients with orthopedic conditions in need of rehabilitation³. It consists of 13 items: eating, grooming, bathing, dressing the upper body, dressing the lower body, toileting, bladder management, bowel management, transfers to bed/chair/wheelchair, transfers to toilet, transfers to tub/shower, locomotion (walking or propelling a wheelchair), and stair climbing. Each FIM-motor item is scored on a 7-point scale (1, total dependence; 7, complete independence). The total FIM-motor score (range, 13–91) is used as an indicator of ability to perform ADL^{4, 5}. FIM-motor scores are obtained weekly in all patients during their convalescent rehabilitation hospital stay. FIM-motor scores on admission, 2 and 4 weeks after admission, and at discharge were analyzed.

Associations between the total FIM-motor score (explanatory variable) and the independence level of individual FIM-motor items (target variables) were analyzed by ordinal logistic modeling^{15–17}, which is used to model multi-level ordinal responses in a simple regression. Taking the example of three-level responses (p_1, p_2, p_3 ; summation equals 1), cumulative probability is calculated at each level (shown below), after which the logarithm of the odds is modeled as two simple regressions for the three-level responses.

$$\log [p_1 / (p_2 + p_3)] = \alpha_1 + \beta_1 X$$

$$\log [(p_1 + p_2) / p_3] = \alpha_2 + \beta_2 X$$

Then, the parameter estimates are assessed for fit to the model (note that a single β and two levels of α are assessed). In this study, the analyses extended the above three-level example to seven-level responses. All statistical analyses were performed using the JMP 14.2.0 software package (SAS Institute, Cary, NC, USA). A p-value <0.05 was considered statistically significant.

RESULTS

Table 1 shows the patient demographics and clinical characteristics. Of 26 patients with an intracapsular fracture, 24 underwent bipolar hip arthroplasty and the remaining two patients received compression screws. A gamma nail was implanted

in all 24 patients with an extracapsular fracture. Median total length of hospital stay was 75 days. Median FIM-motor score was 52.5 on admission to the convalescent rehabilitation hospital and 83 at discharge (Table 1).

Table 2 shows the parameter estimates obtained by ordinal logistic modeling analyses for all 13 FIM-motor items. For each individual FIM-motor item, the fit of the ordinal logistic modeling was statistically significant, indicating that the dataset could be validly interpreted as logistic probabilities. Figure 1 shows logistic curves derived from Table 2. Ordinal logistic curves successfully outlined the probabilistic distribution of the independence levels of FIM-motor items.

As Fig. 1 shows, the steeper logistic curves indicated better model fits, as indexed by R^2 (Table 2). Data for transfers to bed/chair/wheelchair and those for transfer to toilet showed evenly distributed steep curves across the entire range of the horizontal axis. This curve pattern indicated that independence levels (1–7) within the individual FIM-motor item were proportionally associated with total FIM-motor score. In contrast, the curves for bladder and bowel management were flat, indicating weak associations between the independence levels of these items and total FIM-motor scores.

Logistic curves for stair climbing and locomotion were strongly deviated to the right, close to the high end of the total FIM-motor score, indicating that these items were the most difficult (Fig. 1), whereas those for eating and grooming were deviated to the left, indicating that these items were easier than other FIM-motor items (Fig. 1).

Table 1. Patient demographic and clinical characteristics (N=40)

| | | |
|------------------|--------------------------------------|------------------|
| Gender | Male/Female | 11/29 |
| Age (years) | | 81.5 (78.0–87.0) |
| Type of fracture | Intracapsular/Extracapsular | 26/14 |
| Fracture side | Right/Left | 16/24 |
| LOS (days) | Acute care hospital | 15.0 (10.3–20.5) |
| | Convalescent rehabilitation hospital | 61.5 (41.0–72.0) |
| | Total | 75.0 (59.0–91.0) |
| FIM-motor score | Admission | 52.5 (40.3–57.0) |
| | Two weeks after admission | 70.0 (63.3–77.5) |
| | Four weeks after admission | 78.0 (72.3–83.0) |
| | Discharge | 83.0 (79.0–86.0) |

Data are shown as the median (IQR) or number of patients.
FIM-motor: motor components of the Functional Independence Measure; IQR: inter-quartile range; LOS: length of hospital stay.

Table 2. Parameter estimates from logistic modeling

| Item | Coefficient | Intercept | | | | | | R^2 |
|--------------|-------------|-----------|-------|-------|-------|-------|-------|-------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | |
| Eating | -0.0991 | - | - | - | 0.231 | 4.25 | 5.83 | 0.244 |
| Grooming | -0.164 | - | - | 2.56 | 4.49 | 9.11 | 9.68 | 0.424 |
| Bathing | -0.142 | 4.34 | 4.80 | 6.00 | 9.35 | 12.83 | 13.98 | 0.278 |
| Dress up | -0.210 | 3.97 | 5.84 | 8.37 | 10.30 | 13.36 | 13.76 | 0.476 |
| Dress low | -0.259 | 11.59 | 14.12 | 14.76 | 16.12 | 17.41 | 18.10 | 0.470 |
| Toileting | -0.324 | 13.03 | 14.71 | 15.35 | 17.41 | 21.80 | 24.84 | 0.549 |
| Bladder | -0.107 | 3.611 | 4.71 | 5.14 | 5.58 | 5.63 | 8.57 | 0.198 |
| Bowel | -0.076 | 1.00 | 1.23 | 1.61 | 2.05 | 2.87 | 6.67 | 0.126 |
| Bed trans | -0.283 | 7.67 | 8.75 | 11.84 | 15.27 | 17.80 | 22.45 | 0.512 |
| Toilet trans | -0.299 | 8.58 | 9.10 | 12.71 | 15.35 | 19.84 | 24.36 | 0.536 |
| Tub trans | -0.177 | 6.40 | 6.96 | 7.56 | 13.12 | 16.06 | 17.54 | 0.333 |
| Locomotion | -0.262 | 17.11 | - | - | 17.34 | 19.31 | 22.80 | 0.441 |
| Stairs | -0.286 | 19.58 | 19.90 | 20.13 | 20.97 | 23.89 | 26.44 | 0.408 |

All logistic modeling analyses were statistically significant ($p < 0.001$). Locomotion data include scores for walking and for wheelchair propulsion.

Bed trans: transfers to bed/chair/wheelchair; Dress low: dressing the lower body; Dress up: dressing the upper body; Toilet trans: transfers to toilet; Tub trans: transfers to tub/shower; Stairs: stair climbing.

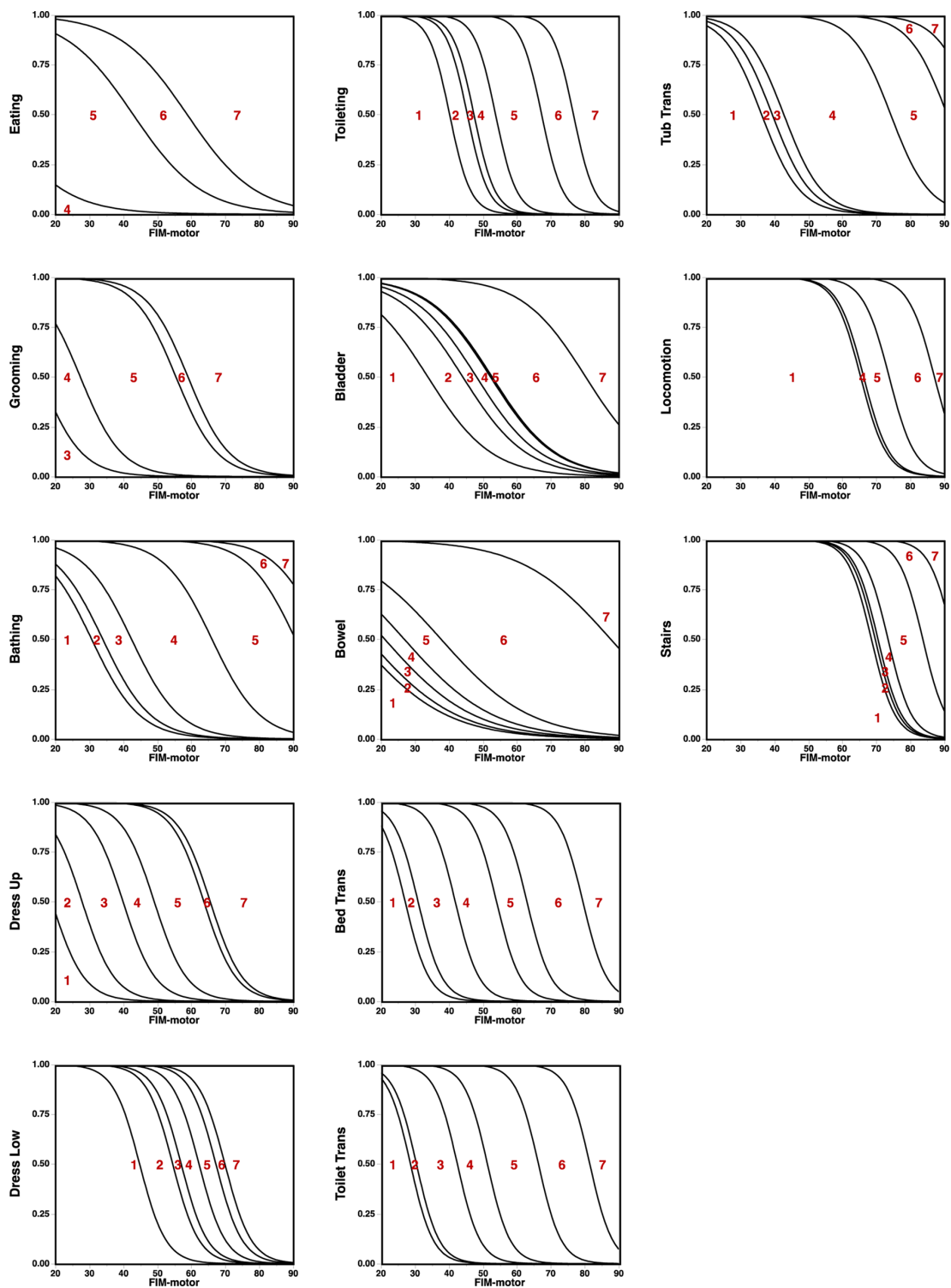


Fig. 1. Logistic probability plots of the relationships between the independence level of each FIM-motor item and total FIM-motor score (group data, total N=160).

The logistic curves are derived from Table 2. The vertical axis shows the logistic probability, and the horizontal axis shows the total FIM-motor score. Probabilities are measured as the vertical distance between the curves for the independence levels (shown in red). For example, in the Bed Trans panel, the first (bottom) curve shows the probability attributed to level 1. The next higher curve shows the probability attributed to level 2. Accordingly, the distance between the first two curves is the probability for level 2. The distance from the top curve to the top of the graph is the probability attributed to level 7.

Bed Trans: transfers to bed/chair/wheelchair; Dress Low: dressing the lower body; Dress Up: dressing the upper body; FIM-motor: motor components of the Functional Independence Measure; Toilet Trans: transfers to toilet; Tub Trans: transfers to tub/shower; Stairs: stair climbing.

DISCUSSION

In this study, we assessed the relationships between the independence level of individual FIM-motor items and total FIM-motor score by applying ordinal logistic modeling to FIM data collected from patients staying in a convalescent rehabilitation hospital after hip fracture. The independence levels of transfers to toilet and bed/chair/wheelchair were proportionally associated with total FIM-motor score. In contrast, the independence levels of bladder and bowel management were weakly associated with total FIM-motor score. Whereas stair climbing and locomotion were the most difficult FIM-motor items, eating and grooming were relatively easy. As shown, although ordinal logistic modeling was statistically significant across all the 13 FIM-motor items, there was considerable variation in the relationship between the independence level of individual items and total FIM-motor score.

Several techniques have been developed to delineate the relationships between individual FIM-motor items and total FIM-motor score, the most popular being the Rasch model^{5, 18)}, which is applied in a wide range of diseases and health conditions³⁻⁹⁾. Previous studies using this model in patients with various diseases and health conditions have found that activities such as eating and grooming are relatively easy to perform, that activities such as transfers to the tub/shower and stair climbing are more challenging, and that activities such as dressing, toileting, and transfers to bed/chair/wheelchair are of intermediate difficulty³⁻⁹⁾. However, these are often indexed as numeric values known as “logits”. In an attempt to develop a more clinically useful reference, we used ordinal logistic modeling¹⁵⁻¹⁷⁾, which generates a probabilistic distribution of the independence level of individual items in reference to the total FIM-motor score (Table 2, Fig. 1). This methodology reveals the distribution of independence levels (1–7) within a given individual FIM-motor item. For example, for the transfer to bed/chair/wheelchair item, the independence level was almost proportional to the total FIM-motor score (Fig. 1). The unique specificity of the ordinal logistic modeling used in this study identified the following specific features in patients who had sustained a hip fracture.

Our data for locomotion revealed a relatively wide area for level 1, nothing for levels 2 and 3, and relatively wide areas for level 4 and higher (Table 2, Fig. 1). The data were collected from patients who had been functionally independent without severe comorbidities before the hip fracture. Naturally, the main target of rehabilitative treatment is regaining the ability to walk. Patients usually undergo surgery after hip fracture. Although gait training was started several days after surgery, most patients used a wheelchair with assistance for locomotion because of postoperative pain. Based on the FIM scoring system, use of a wheelchair with full assistance is interpreted as level 1. However, most of the patients regained their ability to walk as rehabilitation proceeded, resulting in higher FIM-motor scores (level 5 or higher). The medical charts showed that 12 of the 40 patients regained their ability to walk without a cane, 27 were finally able to walk with the assistance of a cane, and 1 remained in a wheelchair but with minimal contact assistance (level 4) for locomotion in terms of ADL.

We also observed specific patterns in the data for eating and grooming. For eating, there were no level 1–3 scores (Table 2, Fig. 1). Not unexpectedly, considering the nature of a hip fracture, there were almost no eating problems (e.g., dysphagia). Similarly, there were no level 1–2 scores for grooming (Table 2, Fig. 1). It is well known from studies in patients with various diseases, including stroke, traumatic brain injury, spinal cord injury, and orthopedic conditions, that eating and grooming are relatively easy FIM-motor items³⁻⁵⁾. Therefore, patients who need more than moderate assistance (FIM-motor level 3) for eating and/or grooming after hip fracture should be investigated for rare geriatric comorbidities, such as amyotrophic lateral sclerosis.

This study has several limitations. First, to minimize variability, we included only those patients who were functionally independent before hip fracture and excluded those with the more common geriatric comorbidities (e.g., Alzheimer’s disease, Parkinson’s disease, and severe sarcopenia), which may have contributed to the relatively good recovery in our cohort. Therefore, care should be taken when extrapolating our findings to the general population. Second, we sampled only patients with first-ever hip fracture. Recurrence of hip fracture on the contralateral side is common in geriatric patients who have suffered hip fracture because of the high prevalence of osteoporosis in these patients. Further studies in the population with bilateral hip fracture are needed. Third, as a result of our strict inclusion criteria, data for only 40 patients were available for analysis. Although some of our findings were statistically significant, caution is recommended when using the current findings as a reference for prescribing a rehabilitative regimen for patients after hip fracture. Further studies in larger sample sizes are needed. Despite these limitations, knowledge of the relationships between the independence level of each FIM-motor item and total FIM-motor score can be useful for facilitating efficient rehabilitative treatment in patients who have sustained a hip fracture.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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