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Original Article

The influence of age on corrected motor FIM effectiveness

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ABSTRACT

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Objective: This study aimed to clarify the influence of age on rehabilitation outcome by using corrected motor FIM (FIM-M) effectiveness, an outcome indicator in which the influence of FIM-M at admission was corrected.

Methods: The subjects were 1,101 stroke patients. The value of A in the equation, Corrected FIM-M effectiveness = FIM-M gain / (A−FIM-M at admission) was set as 42, 64, 79, 83, 87, 89, and 91 points (for FIM-M score at admission of 13−18, 19−24, 25−30, 31−36, 37−42, 43−48, and 49−90 points, respectively). The subjects were divided into 10 groups by age with a 5-year range in which the average of corrected FIM-M effectiveness was calculated.

Results: The mean corrected FIM-M effectiveness was almost constant in five groups below 69 years and decreased almost linearly as age increased in five groups over 70 years.

Conclusion: The outcome decreases almost linearly after the age of 70 years old.

Key words: corrected motor FIM effectiveness, age, outcome

Introduction

With regard to the influence of age on activities of daily living (ADL) gain (ADL at discharge−ADL at admission), many reports have stated that "the elderly have lower ADL gain." On the other hand, some reports have stated that there is no significant difference or that the influence of age is limited [1]. Leung *et al*. [2] conducted multiple regression analysis with age, etc. of stroke patients as explanatory variables and gain of their total score of 13 items in the Functional Independence Measure (FIM) motor scale (FIM-M gain) as a criterion variable, and reported that the regression coefficient of age was −0.24. This means that FIM-M gain decreases by 0.24 point linearly as age increases by 1 year. However, it is not clear whether the relationship between age and FIM gain is really linear, and from what age to what age the linear relationship is seen.

Many reports have used FIM gain as the outcome and so it is likely to be difficult to prove that the outcome of the elderly is lower than that of youths. In FIM gain, "many patients for whom it is difficult to improve the gain are included" at all assistance levels, whereas the gain becomes low due to the "ceiling effect" at light assistance levels (Fig. 1a). In comparison, patients with medium assistance have higher gain in many cases [3]. For this reason, when there are many elderly patients with medium assistance, the average FIM-M gain of the elderly may become higher than that of youths.

Methods to correct the ceiling effect of FIM gain include FIM-M effectiveness: FIM-M gain / (91 points−FIM-M at admission) [4]. This is used to check what percentage of potential improvement has improved by setting the points that may improve as the denominator and the points that actually improved as the numerator. For example, a patient with FIM-M of 81 points at admission has an FIM-M gain of 10 points (91−81 points) at maximum. Values of FIM-M effectiveness are therefore between 0 and 1.

A survey of FIM-M effectiveness in K Hospital resulted in values of less than 0.65 for the FIM-M range of 13−48 points at admission as opposed to constantly around 0.65 for 49−90 points (Fig. 1b) [5]. In other words, FIM-M effectiveness corrects the low values (ceiling effect) for the range of high FIM-M at admission but cannot correct for the range of low FIM-M at admission (Fig. 1b). This is likely to be

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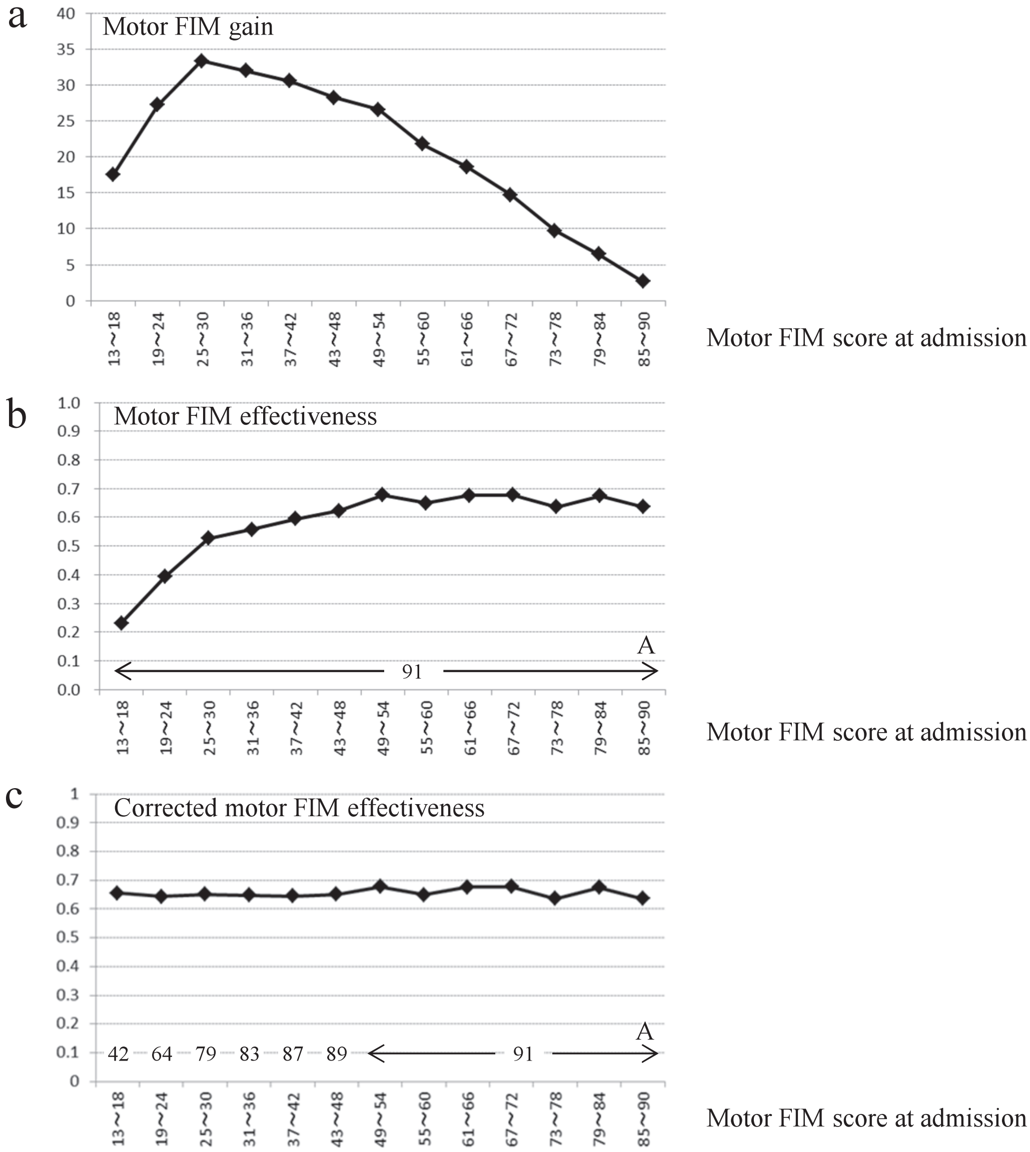

Figure 1. The association between motor FIM score at admission and motor FIM gain (a), motor FIM effectiveness (b), and corrected motor FIM effectiveness (c).
FIM, Functional Independence Measure. A is the parameter from the following equation: Motor FIM effectiveness = motor FIM gain / (A−motor FIM at admission). Fig. 1 of reference [5] was quoted after partial revision.

because of a small number of patients whose FIM-M gain improves to 73−78 points (91 minus 13−18 points) in reality, even though it is possible in theory that among patients with FIM-M of 13−18 points at admission, the values of FIM-M effectiveness are low.

For that reason, Tokunaga *et al*. [5] corrected the constant 91 points in the denominator of FIM-M effectiveness. Specifically, they changed the value of A in FIM-M gain / (A−FIM-M at admission) to 42, 64, 79, 83, 87, 89, and 91 points (in the case of FIM-M of 13−18, 19−24, 25−30, 31−36, 37−42, 43−48, and 49−90 points at admission, respectively). The value of A in the corrected FIM-M effectiveness indicates the limit to which severely affected patients can improve FIM-M as easily as mildly affected patients can improve FIM-M to 91 points at discharge. The FIM-M effectiveness became constantly around 0.65 even for the range of low FIM-M at admission (13−48 points), showing that "corrected FIM-M effectiveness" can be used as an outcome indicator in which the influence of FIM-M at admission is corrected (Fig. 1c) [5].

This study aimed to clarify the influence of age on the rehabilitation outcome of stroke patients by using "corrected FIM-M effectiveness" as the outcome.

Subjects and Methods

A retrospective epidemiological study was conducted. A total of 1,101 stroke patients who were admitted to Kaifukuki rehabilitation wards in K Hospital between

April 1, 2008 and July 16, 2013, after undergoing treatment at an acute hospital, were enrolled. The following patients were excluded: those with subarachnoid hemorrhage, those admitted within 7 days or more than 60 days after onset, those who spent less than 14 days or over 180 days in hospital, those who died in hospital, and those with motor FIM score on admission of 91 points or with motor FIM gain of less than 0 point.

All the required items were available from all subjects, with no missing data. Table 1 shows the basic attributes of the 1,101 subjects. Other than a shorter period between onset and admission, the subjects were very similar to those recorded in the national survey of Kaifukuki rehabilitation wards [6].

This study complied with the regulations of the Clinical Research Ethics Committee of the authors' hospital, and was performed with the permission of staff previously designated by the Clinical Research Ethics Committee. All personal information was converted to data, which was handled in such a way that individuals could not be identified. We used FIM version 3 [7].

Study 1: Relationships between age and corrected FIM-M effectiveness

Corrected FIM-M effectiveness was calculated using the method of Tokunaga *et al*. [5]. Specifically, the value of A in FIM-M gain / (A−FIM-M at admission) was set at 42, 64, 79, 83, 87, 89, and 91 points (in the case of FIM-M of 13−18, 19−24, 25−30, 31−36, 37−42, 43−48, and 49−90 points at admission, respectively). The ages of the subjects were stratified into 10 groups (below 49, 50−54, 55−59, 60−64, 65−69, 70−74, 75−79, 80−84, 85−89, and over 90 years) with a 5-year range. In these age-stratified 10 groups, the average of corrected FIM-M effectiveness was calculated.

Study 2: Differences in corrected FIM-M effectiveness among 10 groups divided by age

The Kruskal-Wallis test was used to assess whether there was a significant difference in corrected FIM-M effectiveness among the 10 groups divided by age. When there was a significant difference, the groups were subjected to multiple comparison using Scheffé's method. A significance level of less than 5% was adopted in both tests.

Study 3: Single regression analysis in subjects aged over 70 years

The range of over 70 years in which the corrected FIM-M effectiveness decreased almost linearly was subjected to single regression analysis (with a significance level of less than 5%) with age and corrected FIM-M effectiveness as explanatory and criterion variables, respectively.

Results

Figure 2 shows the relationships between age and corrected FIM-M effectiveness. The mean values of the corrected FIM-M effectiveness were almost constant in five groups including the below 49 years group to the 65−69 years group whereas they decreased almost linearly as age increased in the five groups including the 70−74 years group to the over 90 years group. The corrected FIM-M effectiveness of the over 90 years group (0.35 on average) was equivalent to 44% of that of the 65−69 years group (0.79 on average).

Corrected FIM-M effectiveness differed significantly among the 10 groups divided by age (Kruskal-Wallis test, $p<0.001$). In the multiple comparison by Scheffé's method, the corrected FIM-M effectiveness of the 75−

Table 1. Clinical characteristics of subjects in this study compared with national survey.

	This study	National survey [6]
Number of patients	1,101	14,011
Sex	Male 670, female 431	56.8% males, 43.2% females
Infarction, hemorrhage	Infarction 706, hemorrhage 395	–
Age	68.9 ± 13.7	72.0
Duration of onset of stroke to admission	21.1 ± 10.4	36.6
Length of hospital stay	81.4 ± 39.9	89.4
Motor FIM score at admission	48.8 ± 25.6	–
Cognitive FIM score at admission	22.8 ± 9.4	–
Total FIM score at admission	71.6 ± 33.0	68.4
Motor FIM score at discharge	67.9 ± 24.2	–
Cognitive FIM score at discharge	26.5 ± 8.4	–
Total FIM score at discharge	94.4 ± 31.4	85.8
Motor FIM gain	19.1 ± 15.26	–
Cognitive FIM gain	3.7 ± 4.5	–
Total FIM gain	22.8 ± 17.9	17.4

FIM, Functional Independence Measure.
Data for this study are expressed as mean ± standard deviation, or number of patients.

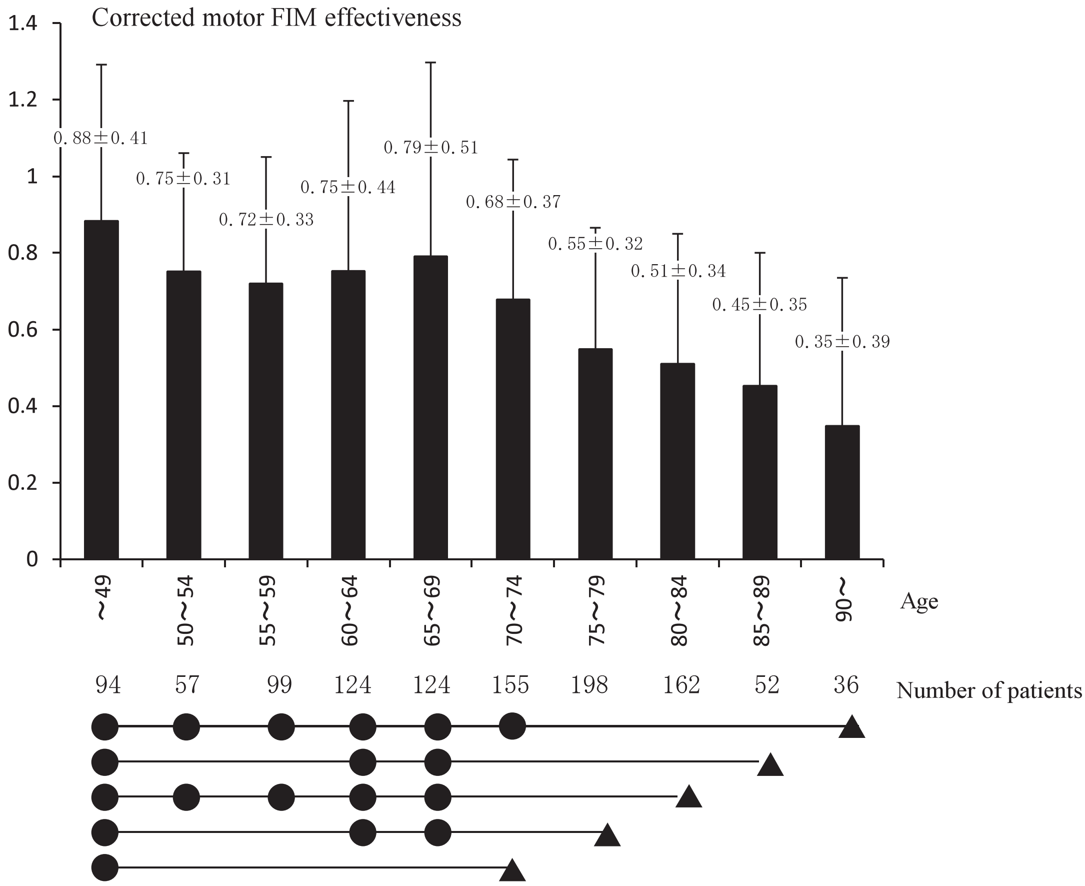

Figure 2. Association between age and corrected motor FIM effectiveness.
Bar graph: Mean ± standard deviation of corrected FIM-M effectiveness in 10 age groups stratified with a 5-year range.
There is a significant difference between ▲ and ● (Scheffé's *F* test, $p<0.05$).

79, 80−84, 85−89, and over 90 years groups was significantly lower than that of the 65−69 years group ($p<0.05$, Fig. 2). No significant difference in corrected FIM-M effectiveness was detected among the below 49, 50−54, 55−59, 60−64, and 65−69 years groups (Fig. 2).

Single regression analysis with age and corrected FIM-M effectiveness as explanatory and criterion variables (X and Y), respectively, in the subjects aged over 70 years provided a regression equation ($Y = -0.0158 \times X + 1.794$) with statistical significance (adjusted coefficient of determination, $R^2 = 0.064$, $p<0.001$).

Discussion

The result of multiple regression analysis is represented by $Y = \mathrm{a}X_1 + \mathrm{b}X_2 + \mathrm{c}X_3$ (X_1–X_3 are explanatory variables whereas a − c are regression coefficients) supposing a linear relationship between the explanatory ($X_1 - X_3$) and criterion (Y) variables. When age is chosen as an explanatory variable and the regression coefficient is −0.24 [2], it is interpreted as "FIM-M gain decreases by 0.24 point as the age increases by 1 year". However, it is not clear whether age and FIM-M gain have "a linear relationship" in "all ages". In addition, the FIM-M gain decreasing along with every 1-year increase of age differed depending on the FIM-M at admission as reported by Black-Shaffer *et al*. [1] and Tokunaga *et al*. [8] instead of showing a constant value such as 0.24 point. In the report by Tokunaga *et al*. [8], they surveyed average FIM gain in a total of 24 groups of stroke patients stratified by total FIM score at admission into six subgroups and age into four subgroups. In the case the FIM at admission was 36−53 points, average FIM gain of the below 59 years and the over 80 years groups were 51.8 and 19.7 points, respectively, whereas in the case of 108−126 points, the average FIM gain of those groups were 5.6 and 7.0 points, respectively [8]. Therefore, subjects need to be stratified by age and FIM at admission when using FIM gain as an outcome in the case of surveying the influence of age on the outcome. The more appropriate method would be to use an outcome indicator in which the influence of FIM at admission is corrected rather than using FIM gain as the outcome.

FIM-M effectiveness cannot correct low outcome from the range of low FIM-M at admission although it corrects the ceiling effect of FIM gain. We believe “corrected FIM-M effectiveness” by Tokunaga *et al*. [5] that solves this defect is an outcome in which the influence of FIM-M at admission is corrected. The present study revealed by using this corrected FIM-M effectiveness [5] that the outcome decreases almost linearly after the age of 70 years old.

Koh *et al*. [4] reviewed reports of surveys on factors influencing rehabilitation outcomes using multivariable analysis searched in PubMed (as of December 31, 2011). According to the review, influences of age on outcomes of stroke rehabilitation were found in 2, 3, 3, and 2 reports in which ADL gain, ADL efficiency (ADL gain / days of hospital stay), FIM effectiveness, and Barthel index effectiveness (Barthel index gain / 100 points−Barthel index at admission) were used as outcomes, respectively [4]. FIM effectiveness and Barthel index effectiveness are the same as rehabilitation effectiveness, relative functional gain, and Montebello Rehabilitation Factor Score. Heinemann *et al*. [9] were the first to report those methods [4]. We hope that the relationships between many factors including age and rehabilitation outcomes will be revealed by multiple regression analysis with corrected FIM-M effectiveness [5] as a criterion variable in future.

This study includes the following limitations: the results were from a single hospital, and the age from which the outcome starts decreasing may differ if the ages are divided with a 1-year range rather than a 5-year range, although we concluded that the outcome starts decreasing from 70 years old.

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