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Methods for Comparing Functional Independence Measure Improvement Degree for Stroke Patients between Rehabilitation Hospitals

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Abstract

When assessing the extent of improvement in Functional Independence Measure (FIM) scores for stroke patients between rehabilitation hospitals-such as Japan's Kaifukuki Rehabilitation Wards—one must note with caution that ceiling effects are present in FIM gain, defined as FIM at discharge minus FIM at admission. In cases where significant differences are present in FIM scores at admission, a variety of techniques may be used, including stratification by FIM scores at admission, FIM effectiveness, and multiple linear regression analysis. Alternative indicators of FIM improvement, which are less sensitive to FIM scores at admission than FIM effectiveness, include corrected FIM effectiveness and the deviation value of FIM gain. When comparing the FIM improvement degree among different hospitals, these methods are augmented by additional techniques, including limiting patients based on FIM scores at admission, case-control study matching FIM scores at admission, and adjustment of FIM gain by standard severity distribution. When comparing FIM improvement degree between hospitals, it is necessary to understand the advantages and disadvantages of these eight methods and analyze it taking into account the difference in patients' severity.

Keywords: FIM gain; Ceiling effect; FIM effectiveness; Stratification; Inter-hospital comparison

Introduction

Researchers attempt to compare the degrees of improvement in activities of daily living (ADL) for stroke patients admitted to convalescent rehabilitation hospitals [1]. However, it is difficult to compare degrees of ADL improvement among groups with different confounding factors such as severity and background factor and it is necessary to devise research design. Nonetheless, in papers investigating the degree of ADL improvement, the opposite conclusion was sometimes reported. For example, regarding the relationship between body mass index and ADL improvement for stroke patients, the sector of patients experiencing the greatest ADL improvement has been variously reported to be very obese patients [2], obese patients [3], underweight and overweight patients [4], overweight patients [5], and normal-weight patients [6,7].

Regarding inter-hospital comparison of ADL improvement, it is not easy to compare the degree of ADL improvement between hospitals with different patients' severities, thus there were few reports [8-13]. In this paper, we describe the problems and countermeasures concerning inter-hospital comparison of improvement degree of Functional Independence Measure (FIM) [14] which is a representative evaluation method of ADL.

FIM Gain, FIM Efficiency, and FIM Effectiveness

FIM evaluates 18 items (13 motor, 5 cognitive) with 1 point (total assistance) to 7 points (fully independent) [14]. Since FIM is the order scale, an improvement from 1 to 2 cannot be considered equivalent to an improvement from 6 to 7. Nonetheless, because the validity of FIM has been tested-with the conclusion that "the total FIM score is a new quantitative indicator that may be effectively used as an interval scale"-research studies have gathered, averaged, and performed multiple linear regression analyses of FIM data, including both motor FIM (13 to 91 points) and cognitive FIM (5 to 35 points). Indicators used to assess the degrees of FIM improvement include FIM gain, FIM efficiency, and FIM effectiveness.

FIM gain

FIM gain is defined as FIM score at discharge minus FIM score at admission. Because the sector of fully-dependent patients includes many for whom FIM improvements are difficult to achieve, FIM gain tend to be small. For the sector of patients requiring only minimal assistance there is a "ceiling effect" that makes FIM gains low for this population as well. In contrast, patients falling near the middle of the spectrum-requiring intermediate levels of assistance—tend to exhibit large FIM gain. Consequently, median values of motor FIM gain exhibit a peaked structure clustered around the admission motor FIM scores near 30 (Figure 1a) [15]. Thus, if significant differences exist in FIM scores at admission between two patients' groups, there is no simple way to compare their respective FIM gains. Instead, researchers resort to methods such as stratification of FIM scores at admission, multiple linear regression analysis, and FIM effectiveness (Figure 1b).

FIM efficiency

FIM efficiency is defined as FIM gain divided by the number of days in hospital. Thus FIM efficiency measures FIM gain per day-in short, the speed of FIM improvement. However, one must note with caution that FIM efficiency is heavily influenced by the length of stay in hospital. Indeed, halving the number of days in hospital has the effect of doubling the FIM efficiency.

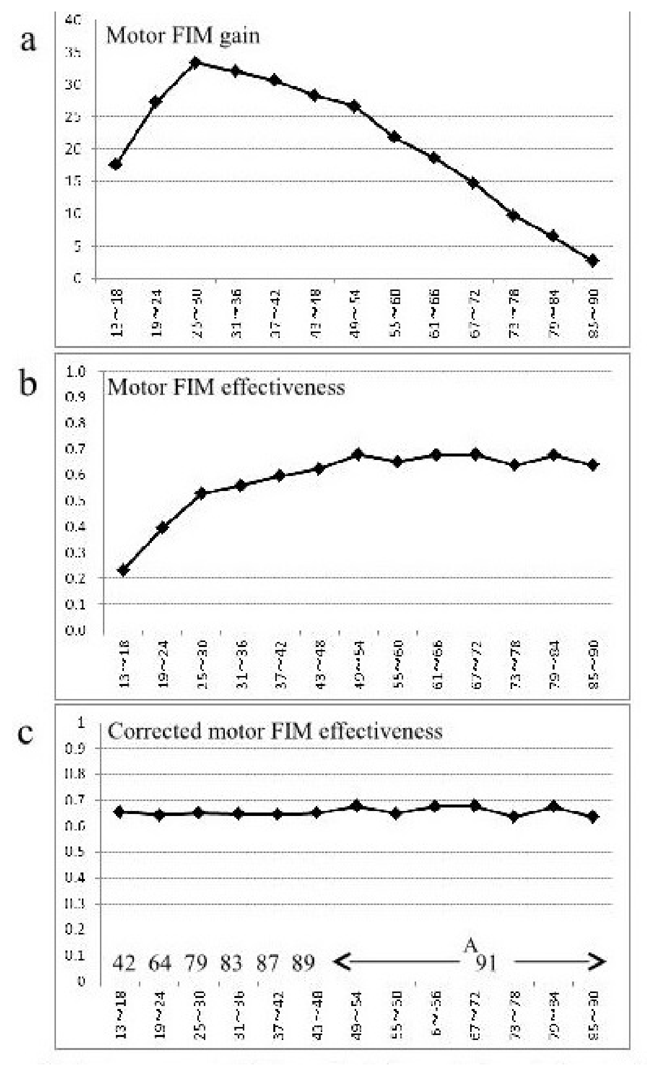

Figure 1: Relationship between motor FIM at admission and three indicators for motor FIM improvement [15].

Consequently, measures of FIM gain over fixed time intervals-such as FIM gain for 2 months-are considered more appropriate indicators for characterizing FIM improvement.

Stratification of FIM scores at admission

The stratification of FIM scores at admission [16-18] is used in cases where one wishes to compare FIM gain among groups of patients with significantly different FIM scores at admission. With regard to the relationship between age and FIM gain, it has been reported that "no significant difference in FIM gain was found between elderly and young patients".

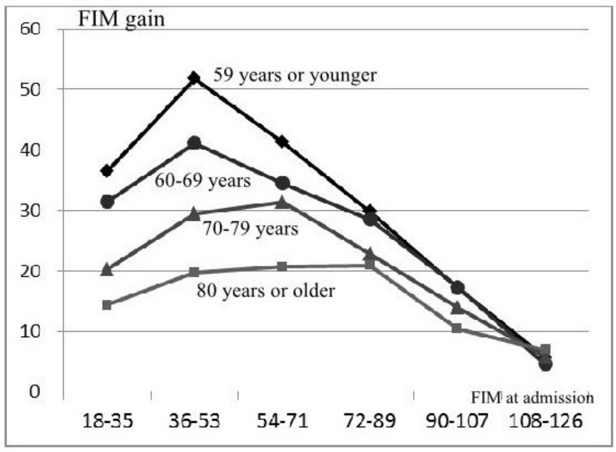

Figure 2: FIM gains in patients stratified into 24 groups (four age groups and six admission FIM groups) [17].

However, this finding is influenced by the ceiling effects (FIM gains tend to be smaller in patients with high FIM scores at admission). Many young patients suffer only from mild diseases and have high FIM scores at admission, thus showing minimal FIM gain due to the ceiling effects. This may contribute to the conclusion that FIM gains for young patients are comparable to those for elderly patients. It has also been reported that "no significant difference in motor FIM gain was found between patients with high and low cognitive FIM scores." This finding reflects the facts that (1) motor FIM gain derivable by patients with high motor FIM score at admission is limited by the ceiling effects, and that (2) cognitive FIM scores are correlated with motor FIM scores. For patients with high cognitive FIM score at admission—who also have high motor FIM scores at admission-the motor FIM gain is limited by the ceiling effects; as a result, the motor FIM gain in such patients is comparable to that in patients with low cognitive FIM scores at admission. By stratifying FIM scores at admission, it is possible to show that FIM gains for elderly patients are smaller than those for younger patients [16,17] (Figure 2), and that FIM gains are small for patients suffering from cognitive diseases [18]. However, the technique of stratification suffers from some disadvantages: the number of factors by which data may be stratified is limited, and stratification requires data for large numbers of patients. Moreover, the results of a stratification study may differ depending on boundaries used-which patient groups are separated from which, and by what statistical thresholds?-and the rationale for, and appropriateness of, any chosen segmentation scheme will surely be questioned.

Multiple linear regression analysis

Another technique used to accommodate differing FIM scores at admission when comparing patient groups is multiple linear regression analysis. This method has the advantage of allowing simultaneous investigation of various factors, not only the single factor of FIM scores

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at admission [19]. However, the predictive accuracy of multiple linear regression analysis is not as high as one might hope [20].

FIM effectiveness

When comparing patient groups with different FIM scores at admission, an indicator that is used in place of FIM gain is FIM effectiveness [21] which corrects the ceiling effects present in FIM gain. The FIM effectiveness is defined as FIM gain/{(126 points)-(FIM scores at admission)}, while the motor FIM effectiveness is defined as motor FIM gain/{(91 points)- motor FIM scores at admission)} [21]. The FIM effectiveness is also known as the Montebello Rehabilitation Factor Score [21]. The denominator in the definition here is the maximum possible improvement in FIM score for a given patient, while the numerator is the actual improvement in FIM score; thus the FIM effectiveness is a value between 0 and 1 which measures the improvement actually achieved as a fraction of the maximum potential improvement possible. Among "studies investigating the influence of various factors on ADL improvement," FIM effectiveness has been used more frequently than FIM gain or FIM efficiency (63 studies using ADL effectiveness, compared to 7 studies using ADL gain and 16 studies using ADL efficiency) [21]. FIM effectiveness corrects for the ceiling effects present in FIM gain, but continues to yields low values for patients with low FIM scores at admission (floor effects) (Figure 1b). Thus the metric of FIM effectiveness, like other metrics, is an indicator of FIM improvement that is influenced by FIM scores at admission.

Indicators of FIM Improvement that are Insensitive to FIM Scores at Admission

Corrected FIM effectiveness

The corrected motor FIM effectiveness is a metric defined in analogy to the usual motor FIM effectiveness but with "the maximum improvement in point score that is mathematically possible" in the calculation replaced by "the improvement in point score that is realistically feasible in practice" [15]. This quantity is computed as (motor FIM gain)/{(A)-motor FIM score at admission)}, where A is defined to be {42, 64, 79, 83, 87, 89, 91 points} respectively for patients whose motor FIM score at admission fell in the range {13-18, 19-24, 25-30, 31-36, 37-42, 43-48, 49-90 points} (Figure 1c).15 The significance of the quantity A is as follows: The ease with which a patient suffering from severe diseases can achieve an FIM improvement of A points is equivalent to the ease with which a patient suffering from mild diseases achieves a full motor FIM score of 91 points at the time of discharge. Note that, for patients who are FIM scores at admission falls in the range 13-48 points, the corrected motor FIM effectiveness may be greater than 1. Numerical values of A differ for different diseases [22]. When comparing FIM improvement degree for a hospital with many patients exhibiting low FIM scores at admission (and thus subject to floor effects) against those for a hospital with few such patients, it is best to correct for floor effects as well. For this reason, a corrected FIM effectiveness statistic with corrections for both floor effects and ceiling effects is appropriate for comparing FIM improvement degree between hospitals [11]. Of course, one might argue that, when comparing groups of patients for which particular factors may be present or absent, it is to be expected that patients with low FIM scores at admission will rarely exhibit significant FIM improvement, and thus that no correction for floor effects should be applied. As yet there is no established conclusion as to whether comparisons of patient groups should be carried out using stratified FIM gain (in which both ceiling and floor effects are present), FIM effectiveness (in which ceiling effects are corrected but floor effects remain), or corrected FIM effectiveness (in which both ceiling and floor effects are corrected). It is also possible to combine stratification with corrected FIM effectiveness. For example, in one study seeking to investigate how FIM improvement degree vary depending on the type of stroke while accounting for the influence of factors such as gender, age, and FIM scores at admission, corrected FIM effectiveness was used to eliminate the effect of FIM scores at admission, while patients were stratified into 2 gender categories, 2 types of stroke, and 11 age categories (Figure 3) [23].

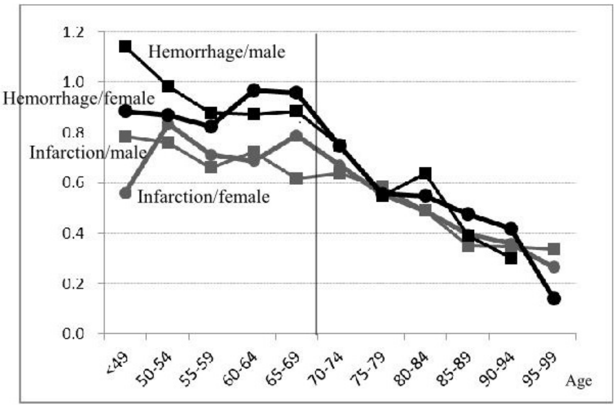

Figure 3: Mean corrected FIM effectiveness by age groups [23].

Deviation value of FIM gain

The deviation value is the result of a conversion that sets the mean value to 50 and the standard deviation to 10; it is used when comparing scores among multiple distributions with differing means and standard deviations. Patients are stratified by FIM scores at admission, the mean value and standard deviation for each patient stratum is calculated, and then the deviation value of FIM gain is computed for each patient as [24] {(FIM gainmean value)×10/standard deviation}+50. This yields an indicator that is insensitive to the effect of FIM scores at admission, making it well-suited for comparing FIM improvement degree between hospitals. However, when comparing groups in which a given factor is present or absent, there remains room for debate as to whether or not one should correct the floor effect (small numerical values for patients with low FIM scores at admission); moreover, this indicator is not widely used. In these ways it is similar to the corrected FIM effectiveness.

Inter-hospital comparison of FIM improvement

For 10 rehabilitation hospitals in the Japanese city of Kumamoto, mean FIM scores at admission range from 39.2-72, a wide spread of variation [25]. Techniques that have been used to compare FIM improvement degree among hospitals with differing mean FIM scores at admission include multiple linear regression analysis [8,9] limiting patients based on admission ADL [10], corrected FIM effectiveness, [11] case-control study in which patients were matched by age and

FIM scores at admission [12], and adjustments of FIM gain based on standard severity distribution [13].

Methods	Multiple regression analysis	Limiting patients	Corrected FIM effectiveness	Case-control study	Standard severity distribution
Comparison among many hospitals	○	△	○	×(two hospital comparison)	○
Subjects	all patients	some patients	full score of FIM at admission and negative FIM gain are excluded	some patients	all patients
Number of patients needed	number of explanatory variables×15 or more is necessary	many are needed to limit patients	many are desirable	one hospital needs several times more patients than the other hospital	many are nedded to stratify
Simultaneous correction of age and FIM at admission	○	×	×	○	△
Correction of numerous factors	○	×	×	×	×
Usage for other than FIM improvement comparison	×	○	×	○	○
Ease of data processing	○	○	×	×	○
Statistical comparison	○	○	○	○	×

Table 1: Five methods to compare FIM improvements among hospitals with different mean FIM scores at admission.○: possible, △: possible but insufficient, ×: impossible. Usage for other than FIM improvement comparison: mean length of stay and mean discharge rate can be compared among hospitals)[9].

Table 1 summarizes the advantages and disadvantages of these 5 methods. As noted above, methods used to compare patient groups with significantly different FIM scores at admission include stratification by FIM scores at admission, multiple linear regression analysis, and alternative indicators of FIM improvement-including FIM effectiveness, corrected FIM effectiveness, and the deviation value of FIM gain-that correct for the ceiling effects present in the FIM gain. Among these, the methods of stratification, FIM effectiveness, and the deviation value of FIM gain might possibly be used for inter-hospital comparisons, although our search yielded no reports of studies using these methods. Thus there are at least 8 techniques available for comparing FIM improvement degree among hospitals.

Multiple linear regression analysis

First, FIM gain was predicted using a multiple linear regression analysis of the patients' data for all hospitals. Patients' data for each hospital was entered into this formula to obtain estimates of FIM gain. Then the ratio (measured FIM gain)/(predicted FIM gain) was computed for each hospital; the larger the value of this ratio, the greater the rehabilitative effectiveness attributed to the hospital [9]. This method has the advantage of being able to account for large numbers of factors; however, as noted above, the predictive accuracy of multiple linear regression analysis is not particularly high, posing problems for the use of this method.

Limiting patients based on admission ADL

The Barthel index (BI) was used to restrict patients based on ADL at admission. There was a significant difference among hospitals in admission BI scores (which range from 0-100 points). But as you exclude 5 highest and 5 lowest BI values, when BI was narrowed down to 5-85 points, there was no significant difference in admission BI scores among hospitals. And we were able to compare BI gains between hospitals [10]. The stratification method produces three results, while the patient-limitation method reveals only one result. The patient-limitation method has the disadvantage of yielding results for only a subset of patients; for example, a hospital that is actively engaged rehabilitation efforts for patients with serious diseases will not necessarily receive high assessment scores. Moreover, it is conceivable that significant differences in admission ADL between hospitals may not disappear even after limiting patients.

Corrected FIM effectiveness

As noted above, the corrected FIM effectiveness corrects for both ceiling and floor effects present in FIM gain and yields an indicator of FIM improvement that is insensitive to the effects of FIM scores at admission. This metric has been used to compare FIM improvement degree among hospitals with differing FIM scores at admission [11].

Case-control study

Case-control study was conducted by selecting a patient in Hospital A (190 patients) and two patients who match age and admission FIM from Hospital B (1,762 patients), then comparing FIM gains between the two hospitals [12]. This approach is problematic for several reasons: only two hospitals may be compared, one hospital needs several times more patients than the other hospital, it is difficult to find matching cases for patients lying at extremes of the age spectrum or the FIM scores at admission spectrum, and the data analysis is cumbersome.

Adjustments of FIM gain based on standard severity distribution

The notion of adjusting FIM gain based on standard severity distribution is similar in spirit to the concept of age-adjusted death rate. Raw death rate is high in rural areas-where elderly residents are numerous-and low in cities, where younger residents are numerous. This sensitivity of raw death rate to the age distribution of the sample population prevents comparison between regions or between years. To address this difficulty, one applies model population distributions to raw death rate segmented into 5-year age strata to compute age-adjusted death rate [26]. Similarly, in the method of FIM gain correction based on standard severity distribution, one determines an adjusted FIM gain by assuming that patients enter each individual hospital with the same FIM scores at admission observed for all hospitals [13]. An advantage of correction based on severity distribution is that it allows hospitals to be compared not only by FIM gain but also by length of stay in hospital or the fraction of patients discharged to their own homes [27]. The disadvantage is that the numerical values of adjusted FIM gain cannot be compared *via* statistical methods.

Problems in the inter-hospital comparison of FIM improvement

Comparisons of FIM improvement degree among hospitals are premised on the assumption that FIM scores at each hospital were accurately measured and sampled. The reliability of FIM samples is issue #1. Issue #2 is the problem of selection bias. Some hospitals exhibit a selection bias when admitting elderly stroke patients, preferentially selecting patients for whom improvements in FIM and eventual at-home discharge are expected; such hospitals will naturally exhibit statistics on FIM improvement for elderly patients superior to those found on average for all hospitals. Issue #3 is that, of the 8 methods outlined above, the question of which method is most suitable for inter-hospital comparisons remains unanswered.

Summary

No fewer than 8 methods have been proposed for comparing FIM improvement degree among hospitals with different mean FIM scores at admission. Among these, multiple linear regression analysis has the advantage that it can account not only for FIM scores at admission but also for many other factors, but its predictive accuracy is problematic. Each of the other methods also exhibits advantages and disadvantages, and it is important to acquire a thorough understanding of the various methods-taking into account variations in the patients' severity-when conducting analyses.

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