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Research article

How Are FIM Gains Improved after Intensive Rehabilitation for Cerebrovascular Diseases?

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Abstract: The purpose of this study was to determine functional independence measure (FIM) gains based on clinical factors after rehabilitation for cerebrovascular diseases, and to determine how FIM scores and FIM gains can predict rehabilitation outcomes. Of the 181 patients in the study 161 suffered strokes (cerebral infarction 107, cerebral hemorrhage 41, subarachnoid hemorrhage 12, subdural hematoma 1). There were also 12 traumatic brain injuries, and 8 other miscellaneous cases. Dementia, higher brain dysfunction, etiology, sex, age, history of cerebrovascular diseases, location involvement, disability severity, duration of hospitalization and period from onset to rehabilitation were analyzed using FIM. FIM gains decreased in relation to an increase in age. Patients with intermediate disability (FIM 41-80) on admission showed significantly higher FIM-total gain on discharge than others. Factors influencing FIM gain were revealed to be age, duration of hospitalization, FIM gain 4 weeks after admission, etiology, disability severity, dementia and past history of cerebrovascular diseases. Multiple regression analysis determined that significant factors to contribute FIM gain were duration of hospitalization, FIM gain at 4 weeks after admission, age, and disability severity. FIM scores and FIM gains could predict rehabilitation outcomes.

Keywords: rehabilitation, functional independence measure (FIM), cerebrovascular disease, stroke, traumatic brain injury

1. Introduction

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 reported that stroke was the third-leading cause of death and disability combined and the second-leading cause of death in the world in 2017 (1,2). Stroke rehabilitation has, therefore, become the most important treatment in caring for stroke patients (3). These patients show improvement after rehabilitation programs, however, the quality and rate of this improvement vary in these patients. Stroke represents the most common cause of adult disability and the second major cause of dementia. Significant functional recovery may develop in the first 3months following the episode (4). Afterward, recovery is associated with cerebral plasticity and cortical reorganization, in great part stimulated by rehabilitation programs (5). The functional independence measure (FIM) is the most widely used standardized outcome measure for rehabilitation in the world. Previous studies and systematic reviews reported that age, marital status, time from stroke onset to rehabilitation, aphasia, neglect, stroke severity presented on the National Institute of Health Stroke Scale, cognitive function, and motor function such as walking distance were associated with the gain score in FIM after stroke rehabilitation (6-8). Most patients with severe stroke do not achieve FIM motor ≥70 after inpatient rehabilitation (9). Older patients and patients with lower admission FIM motor require more attention (10). There are many unknowns, such as what factors relates to the result of the rehabilitation for cerebrovascular disease which was speculated by FIM gain. If we can understand these unknowns for the rehabilitation for cerebrovascular disease, we can estimate the degree of improvement expected by the FIM score and FIM gain.

In this article we took a comprehensive look at not only the rehabilitation of stroke patients but also that of patients with other cerebrovascular diseases, traumatic brain injuries, brain tumors, and meningoencephalitis. All the patients with cerebrovascular diseases underwent the same rehabilitation. We intended to understand their overall rehabilitation outcomes. We estimate the FIM gain after rehabilitation for dementia, higher brain dysfunction, etiology, sex, age, history of cerebrovascular diseases, disability severity, location involvement, FIM gain at 4 weeks after admission, duration of hospitalization and period from onset to rehabilitation.

The purpose of this study was to determine FIM gains based on clinical factors after rehabilitation for cerebrovascular diseases, and to determine how FIM scores and FIM gains can predict rehabilitation outcomes.

2. Materials and Methods

Design

The ethical approval of the study was obtained from Shimada Hospital Ethics Committee (No.2208). Informed consent was obtained from the patients who participated in the study. The research was conducted in accordance with the 2008 Helsinki Declaration of Human Rights. It was a retrospective research project and conducted at a single institution. Patients who suffered from strokes, traumatic brain injuries, brain tumors or meningoencephalitis and received intensive rehabilitation by qualified physical therapists, qualified occupational therapists and qualified speech-language-hearing therapists.

Participants

The inclusion criteria for this study were patients aged 20 years or older who suffered from cerebrovascular diseases (stroke, traumatic brain injury, brain tumor, meningoencephalitis), were admitted to a convalescent hospital, and were undergoing a full-time rehabilitation treatment program 7 days a week from May 2021 to October 2022. To minimize potential bias, we registered all patients who were hospitalized from May 2021 to October 2022 without any artificial manipulation. Patients who refused rehabilitation treatment within 1 week after admission were excluded. Finally 181 patients were registered in the study (Table 1). Ninety patients were male and 91 patients were female. Their mean age was 76.7 ±12.0 years old (range 40 to 102). There were 161 strokes (cerebral infarction 107, cerebral hemorrhage 41, subarachnoid hemorrhage 12, subdural hematoma 1), 12 traumatic brain injuries, 6 brain tumors and 2 meningoencephalitises. The duration of rehabilitation for patients was decided according to degree of disability severity and efficacy of the treatment.

According to the rules of the healthcare system of Japan, patients who were 78 years or younger underwent 3 hours of professional stroke rehabilitation per day (physical therapy 1 hour, occupational therapy 1 hour, speaking therapy 1 hour). Patients who were 79 years or older underwent 2 hours of professional stroke rehabilitation per day (physical therapy 40 minutes, occupational therapy 40 minutes, speaking therapy 40 minutes). When occupational therapy or speaking therapy was not necessary for patients, physical therapy was given instead. Based on the patient's clinical condition, rehabilitation was administered at the physician's request; however, no established rehabilitation protocol existed. The content of each daily program was thus decided by the staff member in charge of rehabilitation. The rehabilitation programs were comprised of mobilization, strength training, range of motion exercise, swallowing training, speech training, ADL(activities of daily living) training and cognitive function training.

Most patients suffered from diseases which needed various kinds of drugs. Patients with neurogenic bladders were treated with bethanechol chloride and/or distigmine bromide and patients with bowel dysfunction were treated with magnesium oxide. Patients who presented with insomnia, depression, agitation, delirium, or violence were given sleeping pills, sedatives, antidepressants, or antipsychotics.

Data collection

For these registered patients, rehabilitation for cerebrovascular disease began at the initial hospital of admissioin and was then handed over to our convalescent hospital. Clinical and demographic features including these etiology, sex, age, history of cerebrovascular diseases, side involvement, location involvement, disability severity, dementia, higher brain dysfunction, duration of hospitalization and period from onset to rehabilitation were analyzed. Functional status was evaluated by using the functional independence measure (FIM). FIM can be used freely, without additional payment in medical research conditions. FIM was widely applied to evaluate participation after stroke (11). The FIM items are broadly classified into total, motor and cognitive categories (FIM-total, FIM-motor, FIM-cognition). FIM involved six aspects of daily function: self-care (eating, grooming, bathing, upper body dressing, lower body dressing, toileting), sphincter control (bladder management, bowel management), transfer (bed to chair transfer, toilet transfer, shower transfer), locomotion (walking/ wheelchair, stairs), communication (cognitive comprehension, expression), and social cognition ability (social interaction, problem solving, memory). In summary, FIM contains 18 items composed of 13 motor tasks (eating, grooming, bathing, upper body dressing, lower body dressing, toileting, bladder management, bowel management, bed to chair transfer, toilet transfer, shower transfer, locomotion[ambulatory or wheelchair level], stairs) and 5 cognitive tasks (cognitive comprehension, expression, social interaction, problem solving, memory). FIM scores were assigned according to a 7-point scale, and the score indicated the amount of assistance required to perform each item (7 = totally independent and 1 = totally dependent or not testable). Scores range from 18 (lowest) to 126 (highest) indicating level of function. FIM scores were analyzed at admission, 4 weeks, 8 weeks, and 12 weeks after admission. For disability severity, FIM score on admission were classified in three groups: severe disability (FIM 40 or lower), intermediate disability (FIM 41-80) and mild disability (FIM 81 or higher). Dementia is any decline in cognition that is significant enough to interfere with independent, daily functioning (12). Alzheimer's is the most common cause of dementia. Higher brain dysfunction is a condition in which brain damage due to illness or accident that results in impairment of cognitive functions such as memory, attention, thinking, language, number operations, and emotional control. Higher brain dysfunction is synonymous with cognitive dysfunction. Higher brain dysfunction is defined by the Ministry of Health, Labor, and Welfare of Japan as having limited ADL and social activities due to cognitive impairment resulting from organic pathology in the brain (13).

Statistical Analysis

The data is presented as the mean ± standard deviation. A non-parametric test (Mann–Whitney U test) was applied to compare the mean value of the two groups. Multiple regression analysis was applied to determine factors to contribute FIM gain. The statistical analyses were performed on StatView for Windows (Version 5.0; SAS Institute Inc. Cary, NC, USA). A p-value of < 0.05 was defined as statistically significant.

Table 1. Patients characteristics

Age	40 ～ 102 （Mean ± S.D. : 76.7 ± 12.0）				
Sex	Male	90	Past history of cerebrovascular disease	No incident	127
	Female	91		One incident	47
Etiology	Cerebral infarction	107		Two incidents	7
	Cerebral hemorrhage	41	Side involvement	Right-sided	75
	Subarachnoid hemorrhage	12		Left-sided	83
	Subdural hematoma	1		Not determined	23
	Traumatic brain injury	12	Dementia	Positive	33
	Brain tumor	6		Negative	148
	Meningoencephalitis	2	Higher brain dysfunction	Positive	122
Location involvement	Over the tent	141		Negative	59
	Under the tent	26	Discharge	Home	127
	Not determined	14		Hospital, nursing home	54

3. Results

Period from onset to rehabilitation were 0 to 41 days (2.2 ± 4.4). The duration of hospitalization at the first hospital was 6 to 114 days (27.3 ± 14.8). The duration of hospitalization at our convalescent hospital for intensive rehabilitation for patients was 10 to 178 days (75.0 ± 34.7).

For 181 patients, FIM-motor gain was 18.3±15.4, FIM-cognitive gain was 3.5 ± 4.0 and FIM-total gain was 21.8 ± 17.8. There was a significant correlation between FIM-total on admission (A) and FIM-total on discharge (B) (B = 22.62 + 0.99×A, the correlation coefficient (r) = 0.857) (Figure 1a). There were not any correlations between FIM-total on admission and FIM-total gain, FIM-motor gain, or FIM-cognition gain on discharge (Figure 1 b-d).

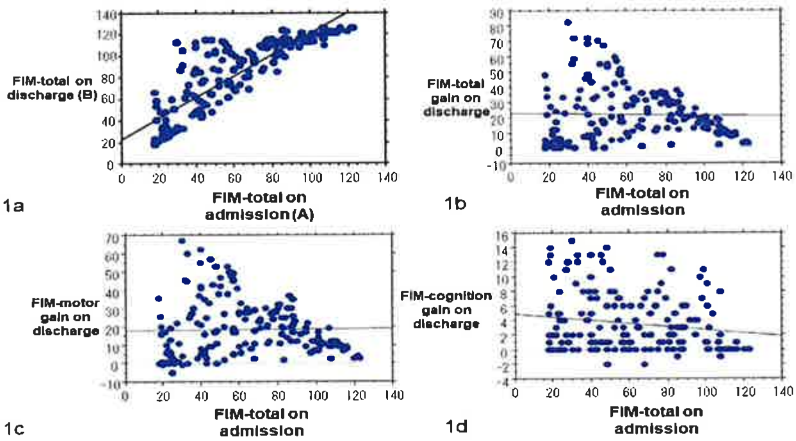


Figure 1a. Relationships between FIM-total on admission (A) and FIM-total on discharge (B). There was a significant correlation between FIM-total on admission (A) and FIM-total on discharge (B): B = 22.62 + 0.99 × A, the correlation coefficient (r) =0.857. **1b-1d:** Relationships between FIM-total on admission and FIM-total gain, FIM-motor gain, or FIM-cognition gain on discharge. There were not any correlations between them.

FIM-total scores were 60.3±30.1 for admission (n=181), 75.0±33.5 for 4 weeks (n=124), 75.0±33.5 for 8 weeks (n=124), and 70.0±35.1 for 12 weeks (n=69). FIM-total gains were 15.2±30.1 for 4 weeks (n=179), 22.9±17.0 for 8 weeks (n=124), and 26.1±21.3 for 12 weeks (n=69). There was a mild relationship between the duration of hospitalization in our convalescent and FIM-total gain on discharge (correlation coefficient (r) = 0.22) (Figure 2a). There was a mild relationship between the period from onset to rehabilitation and FIM-total gain on discharge (correlation coefficient (r) = 0.20) (Figure 2b).

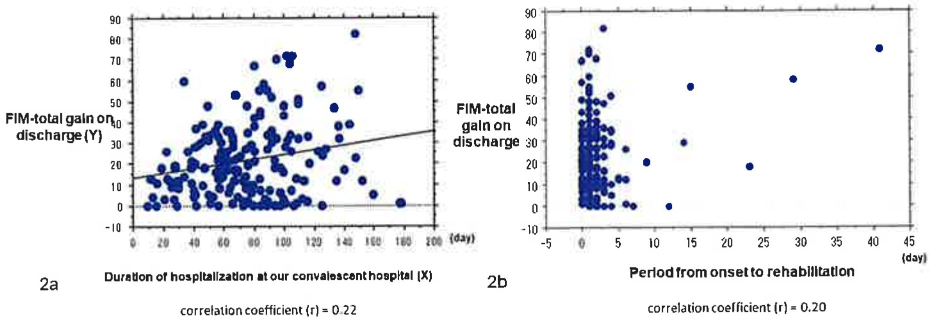


Figure 2a: Relationships between duration of hospitalization at our convalescent hospital and FIM gain on discharge. **2b**: There was a mild relationship between the period from onset to rehabilitation and FIM-total gain on discharge. There were two outlying cases in which FIM gain increased favorably after a delayed introduction of rehabilitation.

There were significant relationships of the correlation coefficient 0.772 between FIM-total gain 4 weeks after admission and FIM-total gain on discharge, the correlation coefficient 0.769 between FIM-motor gain 4 weeks after admission and FIM-motor gain on discharge, and the correlation coefficient 0.820 between FIM-cognition gain 4 weeks after admission and FIM-cognition gain on discharge (Figure 3). There were significant relationships between them.

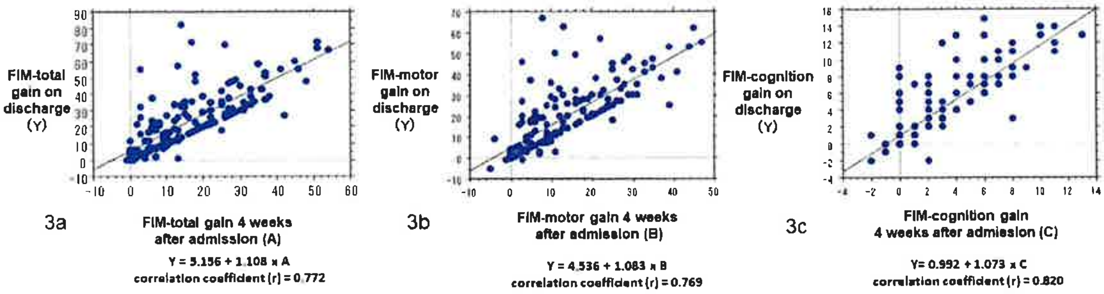
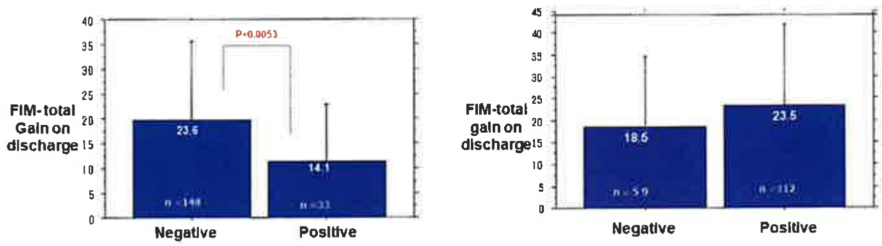


Figure 3. Relationships between FIM gain 4 weeks after admission and FIM gain on discharge. There were significant relationships between them.

Comparisons of FIM-total gain at discharge based on different factors are presented in Table 2. For dementia, FIM-total gain on discharge (23.6 ± 18.4) in patients without dementia was significantly higher than that (14.1 ± 12.4) of patients with dementia (p=0.0053) (Figure 4a). FIM-motor gain on discharge (19.8 ± 15.8) in patients without dementia was significantly higher than that (11.5 ± 11.4) of patients with dementia (p=0.0053). FIM-cognition gain on discharge (3.8 ± 4.2) in patients without dementia tended to be higher than that (2.4 ± 2.7) of patients with dementia (p=0.069). Conversely, FIM-total gain on discharge (23.5 ± 18.4) in patients with higher brain dysfunction tended to be higher than that (18.5 ± 16.2) of patients without higher brain dysfunction (p=0.076) (Figure 4b).



4a Dementia 4b Higher brain dysfunction

Figure 4a: FIM-total gain on discharge in patients without dementia were significantly higher than that of patients with dementia. **4b:** FIM-total gain on discharge in patients with higher brain dysfunction was tended to be higher than that of patients without higher brain dysfunction.

Table 2. Comparisons of FIM-total gain at discharge based on different factors

Factor		FIM gain at discharge	P value
Dementia	Without dementia	23.6 ± 18.4	P=0.0053
	With dementia	14.1 ± 12.4	
Higher brain dysfunction	Without higher brain dysfunction	18.5 ± 16.2	P=0.076
	With higher brain dysfunction	23.5 ± 18.4	
Sex	Male	21.6 ± 18.6	P=0.851
	Female	22.1 ± 17.1	
History of cerebrovascular disease	No incident	23.9 ± 18.9	P=0.051
	One incident	18.0 ± 13.8	
	Two incidents	9.3 ± 12.1	P=0.045
Laterality	Left-sided	22.6 ± 18.4	P=0.302
	Right-sided	19.8 ± 16.1	
	Not determined	25.7 ± 20.8	
Location	Over the tent	21.5 ± 18.2	P=0.988
	Under the tent	21.4 ± 14.6	
	Not determined	36.0 ± 8.9	
Disability severity	Mild disability (FIM 81 or higher)	17.2 ± 8.69	P<0.0001
	Intermediate disability (FIM 41-80)	28.6 ± 17.2	
	Severe disability (FIM 40 or lower)	18.7 ± 22.2	P=0.0054
Etiology	Cerebral hemorrhage	29.3 ± 19.8	p=0.0013
	Subarachnoid hemorrhage	26.8 ± 21.9	
	Traumatic brain injury	21.3 ± 21.4	
	Meningoencephalitis	20.5 ± 23.3	
	Cerebral infarction	19.2 ±15.5	
	Brain tumor	13.0 ± 14.3	
	Subdural hematoma	6.0	

FIM-total gain on discharge (21.6 ± 18.6) of males were the same as that (22.1 ± 17.1) of females. FIM-total gains on discharge decreased in relation to an increase in age. FIM-total gains on discharge were 35.0 ± 21.7 for patients of 49 years old or younger, 31.8 ± 20.4 for 50-59 years old, 29.5 ± 20.3 for 60-69 years old, 22.1 ± 17.3 for 70-79 years old, 18.2 ±14.3 for

80-89 years old, 14.0 ± 17.0 for 90-99 years old, and 8.0 for 100 years old or more (Figure 5a). FIM-motor gains on discharge decreased according to the increase in age as same as FIM-total gains on discharge. FIM-cognition gain on discharge (5.2 ± 5.1) was highest in patients of 60-69 years old. For past history, FIM-total gains on discharge were 23.9 ± 18.9 in patients with no history of cerebrovascular disease, 18.0 ± 13.8 in patients with a history of one incident, and 9.3 ± 12.1 in patients with a history of two incidents (Figure 5b). FIM-total gains on discharge decreased according to the number of incidents of cerebrovascular diseases. FIM-total gain on discharge (22.6 ± 18.4) of left-side involvement tended to be higher than that (19.8±16.1) of right-side involvement, but there was no significant difference. FIM-total gain on discharge (25.7 ± 20.8) of the involvement without the laterality tented to be higher than those of the involvement with the laterality. FIM-total gain on discharge (21.5 ± 18.2) in organs involved over the tent was as same as that (21.4 ± 14.6) in organs involved under the tent.

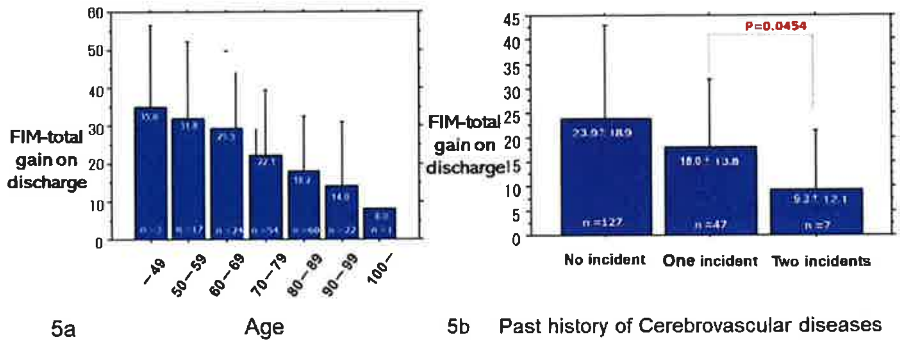


Figure 5a: FIM-total gains on discharge were decreased according to an increase in age. FIM-total gains on discharge were 35.0±21.7 for patients of 49 years old or younger, 31.8±20.4 for 50-59 years old, 29.5 ±20.3 for 60-69 years old, 22.1±17.3 for 70-79 years old, 18.2 ±14.3 for 80-89 years old, 14.0 ±17.0 for 90-99 years old, and 8.0 of 100 years old or more. **5b:** The FIM-total gains on discharge decreased according to incidents of past history of cerebrovascular diseases.

For disability severity, patients with intermediate disability (FIM 41-80) on admission showed significantly higher FIM-total gain on discharge (28.6 ± 17.2) than that (18.7 ± 22.2) of patients with severe disability (FIM 40 or lower) on admission, or than that (17.2 ± 8.69) of patients with mild disability (FIM 81 or higher) on admission (Figure 6a). FIM-total gains on discharge were 19.2 ±15.5 for cerebral infarction, 29.3 ± 19.8 for cerebral hemorrhage, 26.8 ± 21.9 for subarachnoid hemorrhage, 21.3 ± 21.4 for traumatic brain injury, 20.5 ± 23.3 for meningoencephalitis, 13.0 ± 14.3 for brain tumor and 6.0 for subdural hematoma (Figure 6b). FIM-total gain on discharge of cerebral hemorrhage was significantly higher than that of cerebral infarction (p=0.0013). FIM-total gains on discharge tended to be higher in subarachnoid hemorrhage compared to cerebral infarction (p=0.128).

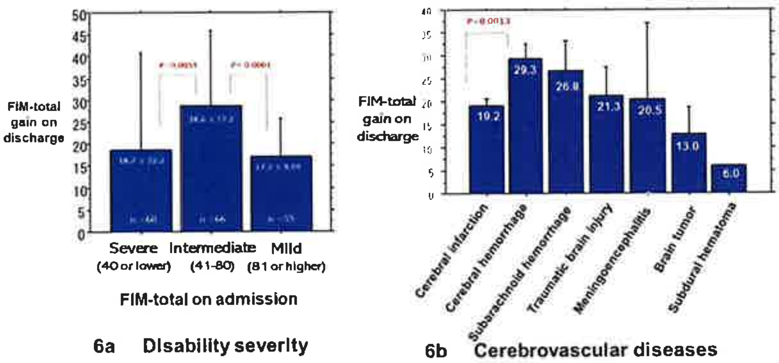


Figure 6a: Relationships between disability severity and FIM-total gains on discharge. FIM-total gain on discharge (28.6 ±17.2) of intermediate disability (FIM 41-80) on admission was significantly higher than that (18.7 ±22.2) of severe disability (FIM 40 or lower) on admission, or than that (17.2±8.69) of mild disability (FIM 81 or higher) on admission. **6b:** FIM-total gains on discharge were 19.2 ±15.5 for cerebral infarction, 29.3 ± 19.8 for cerebral hemorrhage, 26.8 ±21.9 for subarachnoid hemorrhage, 21.3 ±21.4 for intracranial trauma, 20.5 ±23.3 for meningoencephalitis, 13.0±14.3 for resected brain neoplasm and 6.0 for subdural hematoma.

For examining relationships among factors, correlation coefficients (r) between the analyzed factors were presented in Table 3. FIM gain at discharge was related to FIM gain at 4 weeks(r=0772)(a result in Figure 3), age (r=0.354), duration of hospitalization (r=0.217) and period from onset to rehabilitation (r=0.205). FIM score at admission was related to duration of hospitalization (r=0.548) and age (r=0.344).

Table 3. Correlation coefficients between the analyzed factors

	Duration of hospitalization	FIM gain at 4 weeks	Age	FIM score at admission	Period from onset to rehabilitation
Duration of hospitalization					
FIM gain at 4 weeks	0.114				
Age	0.0316	0.255			
FIM score at admission	0.548	0.187	0.344		
Period from onset to rehabilitation	0.122	0.152	0.095	0.122	
FIM gain at discharge	0.217	0.772	0.354	0.069	0.205

Multiple regression analysis was applied to examine factors to contribute FIM gain (Table 4). Significant factors to contribute FIM gain were the duration of hospitalization (p<0.0001), FIM gain at 4 weeks after admission (p<0.0001), age (p=0.0031), and disability severity(p=0.0179). On the other hand, FIM score at admission, past history of cerebrovascular diseases, dementia, period from onset to rehabilitation, sex, etiology or higher brain dysfunction were not significant factors to contribute FIM gain at discharge.

Table 4. Multiple regression analysis for FIM gain

Factor	scores	Regression coefficient	Standard deviation	Standard regression coefficient	P value
Duration of hospitalization	days	0.117	0.027	0.224	< 0.0001
FIM gain at 4 weeks after admission	gain scores	1.031	0.067	0.718	< 0.0001
Age	ages	-0.23	0.077	-0.156	0.0031
Disability severity	intermediate disability :1 severe disability or mild disability: 2	-3.883	1.624	-0.104	0.0179
FIM score at admission	scores	-0.057	0.034	-0.097	0.0986
Past history of cerebrovascular diseases	no incident: 1 one incident: 2 two incidents: 3	-2.014	1.399	-0.062	0.1517
Dementia	negative: 1 positive: 2	-2.945	2.059	-0.064	0.1544
Period from onset to rehabilitation	days	0.152	0.171	0.038	0.3742
Sex	female: 1, male: 2	0.600	1.498	0.017	0.6890
Etiology	hemorrhage: 1 infarction or other etiology: 2	-0.556	1.758	-0.014	0.7524
Higher brain dysfunction	negative: 1 positive: 2	-0.028	1.616	-0.001	0.9863

4. Discussion

In this article we determined the significant factors which influence the functional improvement of rehabilitation in cerebrovascular diseases: the duration of hospitalization, FIM gain at 4 weeks after admission, age, and disability severity. Multiple regression analysis revealed that dementia, higher brain dysfunction, etiology, and past history of cerebrovascular diseases were not significant. Factors influencing the rehabilitation results were age, cognitive impairment, unilateral spatial neglect, ADL before the illness, and period from the onset to hospitalization (14). The significant predictors for "clinically significant functional gain" were also younger age <75 years old, higher Glasgow Coma Scale score at admission, hemorrhagic stroke, intermediate FIM- motor measure (MM) function group (15). Our results are largely in line with those reported in the literature.

FIM gain at dischage

In our patients, mean FIM-motor gain at dischage was 18.3 ± 15.4, mean FIM-cognitive gain was 3.5 ± 4.0 and mean FIM-total gain was 21.8± 17.8. Our results were almost the same as the results from a Shannon Janzen et al. experiment that stroke rehabilitation FIM-motor gain was 18.9 ± 14.0, FIM-cognitive gain was 2.7 ± 3.6 and FIM-total gain was 21.7 ± 15.5 (16). Turner-Stokes L et al. also reported that after stroke rehabilitation FIM-motor gain was 18.4, FIM-cognitive gain was 4.2 and FIM-total gain was 22.6 (17). Standard FIM-total gains at dicharge were revealed to be 21 to 22, and one of the goals of improved rehabilitation in cerebrovascular diseases will be an FIM-total gain score of greater than 22 at the time of discharge.

FIM gain 4 weeks after admission

We realized that improving the physical condition of patients is based on FIM gain 4 weeks after admission, not on the FIM score on admission. There was a significant relationship of the correlation coefficient 0.772 between FIM-total gain 4 weeks after admission and FIM-total gain on discharge. FIM gain 4 weeks after admission was revealed to be a prognostic predictor of cerebrovascular diseases. Multiple regression analysis revealed FIM gain 4 weeks after admission was a significant factor to contribute FIM gain. There have been no reports of FIM gain 4 weeks after admission in the literature.

Dementia and/or higher brain dysfunction

FIM-total gain, FIM-motor gain and FIM-cognition gain in patients without dementia were significantly higher than those of patients with dementia. Both total and motor FIM scores at admission and discharge, and their respective FIM gain scores at discharge were higher in non-pre-stroke dementia compared with pre-stroke dementia patients ($P < 0.001$) (10). Despite severe neurologic impairment(s) and disability, cognitively impaired stroke patients made significant functional gains while undergoing rehabilitation and many can be regulated to getting better at home (18). Managing dementia can lead to better functional recovery during rehabilitation (19). Most of the cognitive improvement took place within 6 months (20). Conversely, FIM-total gain with higher brain dysfunction tended to be higher than those of patients without higher brain dysfunction. Higher brain dysfunction refers to deficits in intellectual functions, such as language, thinking, memory, behavior, learning, and concentration, resulting from organic brain lesions. Damage to neuronal networks in the bilateral frontal and temporal lobe appeared to play the most important role in higher brain dysfunction (21). Although the results of multiple regression analysis showed that dementia or higher brain dysfunction was not significant, management of dementia and higher brain dysfunction is essential for contributing FIM gains. Post-stroke cognitive impairment is associated with poorer outcomes and greater disability.

Age

FIM-total gains decreased according to increases in age. There was a report that the age group 65–74 years old were obviously not yet too old to be labelled with limited rehabilitation potential; this age group was associated with better functional gain when being compared with the age group 75-84 years old and the age group>85 years old (15). Younger ages were associated with better functional gain in both univariate and multivariate analysis (22,23). It is common that FIM improvement is constant in younger patients under 69 years old, and decreasing linearly in older patients over 70 years old (24).

Disability severity

Functional improvement was observed in all the groups in our study, but the improvement in the patients with intermediate disability (FIM score 41–80) was significantly higher than that in patients with severe disability (FIM 40 or lower) or mild disability (FIM 81 or higher). Inouye et al. divided their patients into 3 groups according to FIM admission score and found that the patients who were moderately affected at admission showed higher FIM gain levels than those who were severely affected (25). Stroke patients in the intermediate FIM-motor function group generally had the best FIM-motor gain (26). Patients with intermediate disability (FIM score 41–80) would get the best outcomes after rehabilitation in cerebrovascular diseases.

Period from onset to rehabilitation and duration of hospitalization

The Intercollegiate Stroke Working Party (ICSWP) published the 5th edition of the *National clinical guideline for stroke* in October 2016 (27). It provides the most up to date and comprehensive overview of the management of strokes available, covering the whole of the pathway from acute care to longer term management. The patients are treated by an rehabilitation program for 2-3 hours every day, 7 days/wk. ICSWP recommends that stroke rehabilitation should begin 24-48 hours after a stroke and treatment and care should be reviewed at six months (27). There was a mild relationship between the period from onset to rehabilitation and FIM-total gain on discharge (correlation coefficient (r) = 0.20). There were two outlying cases in which FIM gain increased favorably after a delayed introduction of rehabilitation. These data in our study represented an opposite correlation from the published literature: the shorter the period from onset to rehabilitation was, the greater the FIM total gain at discharge was (6-8, 10). There was a mild relationship between the duration of hospitalization in our convalescent and FIM-total gain on discharge (correlation coefficient (r) = 0.22). There have been no reports of a relationship between the duration of hospitalization and FIM-total gain on discharge. Patients with cerebrovascular diseases would need enough rehabilitation period of 3 months, especially during a patient's FIM gain increasing.

Other Clinical factors

FIM-total gain (21.6 ± 18.6) of males were the same as that (22.1 ± 17.1) of females. FIM gain was decreased according to repeating cerebrovascular diseases. No history of previous cerebrovascular diseases was correlated with improved FIM-total gain. FIM-total gain of left-side involvement tended to be higher than that of right-side involvement. FIM-total gain of the location without the laterality tended to be higher than that of locations with the laterality. FIM-total gains were same in organs involved under the tent and organs involved over the tent. Patients with bilateral hemiparesis had significantly greater FR (functional recovery) after stroke than patients with unilateral hemiparesis (28). The magnitude of change was significantly higher for patients with bilateral hemiparesis (28). FIM-total gain of cerebral hemorrhage was significantly higher than that of cerebral infarction. Krishnan RR et al. reported that functional improvements after rehabilitation of cerebral hemorrhage was better than that of cerebral infarction (FIM-hemorrhage Δ 27 vs. FIM-infarction Δ 21, p = 0.05), despite significantly worse initial stroke severity (28). Multiple regression analysis showed that etiology (hemorrhage VS infarction or other etiology) was not significant for contributing FIM gains. There is evidence that recovery was not limited to this time period alone. In the past, the observation of spontaneous recovery after stroke has misled some authors to believe that recovery of upper extremity function is intrinsic and that little can be done by therapists to influence it.

Future plans and personalized rehabilitation strategies for the rehabilitation of the cerebrovascular diseases

Patients who were younger, or whose FIM score 41-80 at admission, would be able to get a good FIM gain with rehabilitation. On the other hand, patients who were older, or whose FIM score 40 or lower, would not be able to get a good FIM gain with rehabilitation. Such patients need to improve thier cognitive abilities. Furthermore, the rehabilitation of cerebrovascular diseases has to start quickly after onset, and will take a significant amount of time, especially during the initial increase in a patient's FIM gain. Patients who are 100 years old or more show very limited FIM gains after the rehabilitation, so they should be recommend for nursing care, not rehabilitation.

In this study, we realized spasticity of limbs, hemiplegia and aphasia were big difficulties to patients and reduced FIM gain. In future research and personalized rehabilitation strategies, we will investigate botulinum toxin treatment for spasticity, repetitive transcranial magnetic stimulation (rTMS) treatment for hemiplegia and aphasia after stroke, and virtual reality for upper limb movement disorders. Botulinum toxin treatment improves spasticity of muscles and increases rehabilitation effectiveness (30). For treatment for hemiplegia and aphasia rTMS-mediated stroke rehabilitation are also elucidated with the intention to accelerate its widespread clinical application (31). VR-supported upper extremity exercise therapy can be effective in improving motor rehabilitation results (32). Future research into these topics will likely lead to individual rehabilitation.

Study limitations I have to keep in mind that the research has five limitations. First, it was a retrospective research project and was conducted at a single institution. Second, the number of patients with cerebrovascular diseases were limited to only 181. In the research, we intended to register all the patients with cerebrovascular diseases who were older than 20 yrs and were treated in the full-time treatment program of rehabilitation 7 days/wk from May 2021 to October 2022 to get a complete picture of patients undergoing rehabilitation. At the result it was found that the number of patients was low in some etiologies. A negative is the limited number of patients in some etiologies. For a more accurate assessment, additional patients with cerebrovascular diseases and more extended follow-up studies are necessary. Third, this study did not have a control group. In private convalecent hospitals, it is rather difficult to add a control group with cerebrovascular diseases for comparison to a study group. In the control group patients cannot get rehabilitation. Most patients with cerebrovascular diseases want to get rehabilitation because there is evidence of the efficacy of this treatment. Forth, after discharge from our hospital, most patients underwent follow-up observation at their family doctors, while others were admitted to other hospitals or nursing homes. Long term outcomes of rehabilitation for cerebrovascular diseases are not clear yet, so we have work with their home doctors, hospitals and nursing homes, and evaluate the long-term outcomes. Fifth, selection bias might be present in the study. These patients with cerebrovascular diseases would be more interested in healthcare and want to get rehabilitation compared to the broader population with cerebrovascular diseases.

5. Conclusions

Improved FIM gain scores after stroke rehabilitation in cerebrovascular diseases were correlated with the duration of hospitalization, FIM gain at 4 weeks after admission, age, and disability severity, but not with dementia, higher brain dysfunction, etiology, and past history of cerebrovascular diseases. We can extrapolate FIM gain at discharge from FIM gain 4 weeks after admission. FIM scores and FIM gains can predict rehabilitation outcome in cerebrovascular diseases.

Supplementary Materials: none

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