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Original Article

Influence of increased amount of exercise on improvements in walking ability of convalescent patients with post-stroke hemiplegia

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Abstract. [Purpose] This study aimed to determine the effects of increased amount of physical therapy exercise on improvements in the walking ability of patients with stroke. [Subjects and Methods] The subjects were selected from patients with stroke who were hospitalized in the convalescent rehabilitation ward, and included 91 patients who received physical therapy for 2.5–3 exercise sessions per day during 2005–2006 (PT3unit group), and 86 patients who received physical therapy for 4.5–6 exercise sessions per day during 2010–2015 (PT6unit group). The functional independence measure (FIM) score evaluates the walking ability of patients during hospital admission, 2 and 4 weeks after admission, and at discharge. The FIM score was stratified according to the degree of lower limb motor paralysis and subsequently compared between groups. [Results] Among the patients with complete paralysis and severe paralysis, the FIM-Walking scores at 4 weeks after admission and at discharge were significantly higher in the PT6unit group than in the PT3unit group. No significant differences were found between the PT6unit and PT3unit groups for patients with mild and moderate paralysis. [Conclusion] Higher amounts of physical therapy exercise contributed to improvements in the walking ability of patients with complete and severe lower limb paralysis.
Key words: Stroke, Walking ability, Amount of exercise

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INTRODUCTION

Improvements in the walking ability of patients with hemiplegic stroke remain one of the important issues in rehabilitation. Interventions that aim to improve the walking ability of patients with stroke have been reported in many studies. According to a study by Kwakkel G et al.[1)], among the patients who underwent normal physical and occupational therapies, those who performed exercises for the lower limbs (i.e. a 30-min period of ambulatory exercise) had improved walking ability than those who performed additional exercises for the upper limbs, or patients who did not perform any additional exercise. In a study by Dean CM et al.[2)], patients who performed circuit exercises, which involved mainly muscle strengthening exercises for the lower limbs, demonstrated improved walking speeds and endurance compared to patients who performed additional exercises for the upper limbs. In addition, ambulatory exercise has been reported to improve walking speed and endurance compared to other forms of exercise[3)]. Peiris C et al.[4)] performed a meta-analysis on hospitalized patients with stroke who were in the acute and subacute phases, and reported that increased physical therapy exercises shortened the duration of hospitalization and contributed to the improvement in walking ability of these patients. However, to our knowledge, similar studies have not been performed in a convalescent rehabilitation ward.

In Japan, the fee-for-service system for rehabilitation was revised in 2006, resulting in removal of the daily upper limits on the number of exercise sessions for a patient in a convalescent rehabilitation ward. The daily exercise sessions were

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increased from 6 sessions (2 hr) to 9 sessions (3 hr). Furthermore, the upper limit (3 exercise sessions totaling 1 hr per day) was abolished and replaced with physical, occupational, and speech-language-hearing therapies. The belief that increasing the amount of exercise duration leads to better outcomes should be verified.

Depending on the differences in the maximum number of exercise sessions limited by the medical insurance system, we examined the effects of increasing the amount of physical therapy exercise on the improvement in walking ability of patients with stroke.

SUBJECTS AND METHODS

This study included patients with hemiplegic stroke who were hospitalized in and discharged from our convalescent rehabilitation ward, and underwent the "FIT program"[5] rehabilitation system that was developed by our hospital. We included 239 patients who completed a maximum of 6 daily exercise sessions (hereinafter called the "first term group") and 707 patients who completed a maximum of 9 daily exercise sessions (hereinafter called "the latter term group"). These exercise limits were specified by the medical insurance system between April 2005 and March 2006 for the first term group, and between April 2010 and March 2015 for the latter term group. In the first term group, 128 patients completed a mean number of physical therapy exercises fewer than 2.5, and were excluded from the study. In the latter term group, 619 patients were excluded from the study as they completed a mean number of physical therapy exercises fewer than 4.5. Furthermore, in order to equalize and compare the patient characteristics at admission between both groups, the patients whose period from onset to admission to the ward was <14 days or ≥61 days, as well those patients whose length of stay in the ward was <28 days, were also excluded from the study. These excluded patients included 20 patients in the first term group and 2 patients in the latter term group. As a result, the final study subjects consisted of 91 and 86 patients in the first (PT3unit group) and latter term groups (PT6unit group), respectively (Table 1). The attending physicians explained the study to all patients and their families, and obtained consent from them. This study was performed after an approval by the ethics committee of our hospital.

The requirement for admission to the convalescent rehabilitation ward was at the discretion of the physicians of the rehabilitation department. Patients were discharged from the ward if their dysfunction and disability had improved and their condition remained steady. The number of exercise sessions was determined based on the physicians' prescriptions rather than randomization. For patients who needed speech-language-hearing therapy, the required number of exercise sessions was set aside for speech-language-hearing therapy, while the remainder of the 6 or 9 exercise sessions focused on physical or occupational therapies, depending on the ratio of the number of hospitalized patients to the number of therapists. The prescribed physical therapy (PT) consisted mainly of range of motion, muscle strengthening, maintenance of standing up and standing positions, ambulatory, and stepping exercises. In addition, for patients who required orthosis for the lower limb, these were manufactured and used during the exercises. No changes were made to the prescription policies for the upper limits of 6 and 9 exercise sessions.

PT exercises were performed based on the risk management instructions provided by the attending physicians.

The following information was extracted from the hospital's patient database: age at admission; gender; diagnosis; paralytic side; period between onset of stroke and admission to our convalescent rehabilitation ward (hereinafter called "time after onset"); number of days spent in the ward; functional independence measure[6] scores, which evaluates the patients' walking ability (hereinafter called "FIMW") during admission, 2 and 4 weeks after admission, and at discharge; and hip-flexion, knee-extension, and foot-pat tests for motor function of the paralyzed lower limbs in the stroke impairment assessment set (SIAS)[7].

To compare the FIMW courses, the total scores of the 3 motor function items for the paralyzed lower limbs at admission (hereinafter called "SIAS for the paralyzed lower limbs") were calculated and stratified into the following classes: complete paralysis (0 points), severe paralysis (1–5 points), moderate paralysis (6–10 points), and mild paralysis (11–15 points).

Table 1. Demographic and clinical data of all the subjects

	PT6unit Group	PT3unit Group
Number of patients	86	91
Age (years)	65.2±12.6	68.3±11.2
Gender (Male, Female)	47, 39	52, 39
Diagnosis (Hemorrhage, Infarction)	43, 43	46, 45
Paralytic side (Right, Left)	26, 60	26, 65
Time after onset (days)	31.1±11.5	34.0±11.9
Number of days spent in ward (days)	72.8±20.5	69.1±23.2
Gain of FIMW score	2.5±0.9*	1.9±1.1

*$p < 0.05$

Bonferroni test was used for intra-group comparisons. Mann-Whitney test was used for comparisons between groups at each period. In addition, the score gain (hereinafter called "FIMW-gain") obtained by subtracting the score at admission from the FIMW score at discharge was calculated and compared between the groups. The Mann-Whitney test was used for comparisons of age, time after onset, and the number of days spent in the ward between the groups. The χ^2 test was used for comparisons of the gender, paralytic side, and percentage of diagnosis between the groups. Statistical analysis was performed by using SPSS version 16.0, and the statistical significance level was set at <5%.

RESULTS

The FIMW scores are shown in Table 2. In the PT6unit group, the FIMW scores in all classes improved compared to the admission score, according to the degree of paralysis. In contrast, the complete paralysis class showed no improvement in the FIMW score compared to the FIMW score at admission in the PT3unit group. The rest of the classes showed significant improvements. In the patients with complete paralysis and severe paralysis, the FIMW scores at 4 weeks and discharge were significantly higher in the PT6unit group than in the PT3unit group. Table 3 shows a comparison of age, diagnosis, affected side, time after onset, number of days spent in ward, and the FIMW-gain between the groups. In the complete paralysis class, age was significantly lower in the PT6unit group than in the PT3unit group.

DISCUSSION

This study revealed that patients who increased their number of PT exercise from 3 to 6 exercise sessions demonstrated improvement in their walking ability, especially in the patients with complete paralysis or severe paralysis of the lower limbs.

Previous studies have shown that walking ability can be improved by various physical therapy interventions[1–3, 8–11]. In our study, physical therapy was performed based on movement exercises consisting mainly of general function exercises and walking, without any special procedures. Therefore, it was believed that this study could be used in order to determine simply how an increase in the exercise amounts influenced improvements in walking ability.

In the complete paralysis class where the patients had motor palsy in their lower limbs (SIAS score of 0 points for the paralyzed lower limbs), the median FIMW score at admission was 1 point in both groups. In a study by Tanino et al.[12], the authors reported that improving the FIMW score of 1 point at admission was difficult for patients with stroke in the convalescent rehabilitation ward. The median FIMW score at discharge was 2 points for patients that were paralyzed in both lower limbs. In our study, the improvements in FIMW score that were observed in the PT3unit group were equivalent to

Table 2. The course of the FIMW

	Admission	2 week	4 week	Discharge	
All					
PT6unit Group	3 (3.0±1.2)	4 (3.7±1.3)	5 (4.4±1.3)	6 (5.5±0.9)	A**, B**, C**, D**, E**, F**
PT3unit Group	3 (3.3±1.4)	4 (3.9±1.5)	5 (4.4±1.6)	5 (5.2±1.3)	A**, B**, C**, D**, E**, F**
SIAS0					
PT6 unit Group	1 (1.6±0.8)	2 (2.2±1.2)	3 (2.7±1.1)	4 (4.5±0.8)	B*, C**, E*, F*
PT3 unit Group	1 (1.0±1.0)	1 (1.2±0.4)	1 (1.3±0.5)*	2.5 (2.3±1.2)*	
SIAS1–5					
PT6 unit Group	3 (2.6±0.9)	4 (3.4±1.2)	4 (4.2±1.3)	6 (5.5±0.7)	A**, B**, C**, D**, E**, F**
PT3 unit Group	3 (2.6±1.1)	3 (3.3±1.1)	4 (3.6±1.1)*	5 (4.9±1.0)*	A**, B**, C**, D*, E**, F**
SIAS6–10					
PT6 unit Group	4 (3.2±0.9)	4 (4.2±0.6)	5 (4.7±0.6)	6 (5.6±0.6)	A**, B**, C**, E**, F**
PT3 unit Group	4 (3.7±1.1)	5 (4.3±0.9)	5 (4.9±1.2)	6 (5.5±1.0)	A**, B**, C**, D*, E**, F*
SIAS11–15					
PT6 unit Group	4 (4.1±0.6)	5 (5.0±1.1)	6 (5.8±0.8)	6 (6.1±0.6)	C**, E**
PT3 unit Group	4 (4.3±1.3)	5 (5.0±1.1)	6 (5.7±1.1)	6 (6.0±0.9)	A**, B**, C**, D*, E**

A: Significant differences between the admission and 2 week
B: Significant differences between the admission and 4 week
C: Significant differences between the admission and Discharge
D: Significant differences between the 2 week and 4 week
E: Significant differences between the 2 week and Discharge
F: Significant differences between the 4 week and Discharge
$^{*}p < 0.05$
$^{**}p < 0.01$
In SIAS0 and SIAS1–5, It showed a difference between the groups in 4 weeks and in Discharge.

those reported in previous publications[12], while the PT6unit group showed great improvements beginning at the 4th week of admission. This suggests that the increased amount of PT exercise contributed to improvements in the walking ability of patients with hemiplegic stroke. Patients with more severe disorders have a fear of falling, and they need assistance to maintain their postures. Therefore, the amount of exercise decreases[13]. Increases in the total amount of physical therapy exercise were assumed to result in sufficient time for ambulatory exercises, and this promoted motor learning.

In addition, for patients in this class with lower activities of daily living (ADL) raised concerns about progression of disuse muscle atrophy since they had the tendency to be inactive with lower amount of daily exercise (e.g., resting in bed)[14]. Nevertheless, by performing high intensity exercises, the PT9unit group improved their walking ability without disuse muscle atrophy. For patients with stroke who were in the convalescent phase, Nobotachi et al. pointed out the difficulties of detecting differences in the recovery of motor functions in patients with severe paralysis based on the effects of increased amount of exercise[15]. The increased physical therapy exercise may be effective for promoting motor learning for walking, rather than for improving motor function.

Additionally, the increase in amount of exercise was clearly effective in patients with severe paralysis of the lower limbs (SIAS score of 1–5 points for the paralyzed lower limbs). For this class, increasing the number of exercise sessions has been reported to improve the motor function of the proximal paralyzed lower limbs, particularly the hip and knee joints[15]. Motor palsy of the lower limbs may influence the improvement in walking ability of patients with hemiplegic stroke[16, 17]. The function of the hip and the knee joints are believed to be important for the attachment of an ankle foot orthosis. In the subjects from the PT6unit group in the present study, we believe that increased amount of exercise improved the proximal motor function in the subjects' paralyzed lower limbs, resulting in improvements in their walking abilities.

In contrast, for the patients in the moderate (SIAS score of 6–10 points for the paralyzed lower limbs) and mild (SIAS score of 11–15 points for the paralyzed lower limbs) classes, no apparent differences were found in the walking ability associated with increased amount of physical therapy exercise. All median FIMW scores at admission of the subjects in these classes were 4 points. Since the degree of independence in the patients was relatively high in these classes, the patients performed stand-up and ambulatory exercises voluntarily after physical therapy, and actively performed exercises in the ward with assistance from the ward staff and the their families. Therefore, the additional effects of voluntary training[18] that influenced the amount of PT exercise were difficult to determine.

This study had some limitations. We considered the amount of exercise as the total amount, and did not perform content analysis of the physical therapy exercises. The present study was also not stratified according to higher brain dysfunction. In addition, although the subjects of the two groups of PT3unit group and PT6unit group were respectively selected from two year intervals of 2005–2006 and 2010–2015 under the each condition, the number of patients of the two year intervals was different and we had more patients in the 2nd year interval. While the number of PT3unit group patients cover a higher percentage of the whole patients of the 1st year interval, the number of PT6unit group patients include a lower percentage of the large number of patients in the 2nd year interval. In future, examining these issues is necessary because of the potential for bias. Because of the low percentage of reporting from the acute-care hospital to the convalescent rehabilitation ward, we were unable to classify the type of stroke. When the profiles of patients with complete paralysis in both groups were compared, the ages of patients in the PT6unit group were significantly lower than that of patients in the PT3unit group. After investigation of the association between the increased amount of exercise and the age-specific ADL improvement in patients with stroke in the convalescent ward, it was found that the ADL was greatly improved in patients who were aged in their 60s with low ADL compared to patients who were 70 years or older[19]. Although the age differences may influence these results, these issues will be addressed in future studies because we did not examine them in this study, due to the small sample sizes.

In the future, we will analyze details such as the contents of the physical therapy exercise and the exercise time distribution, in order to add to the discussion, and examine data that is stratified according to age and stroke type.

Table 3. Demographic and clinical data of the subjects stratified to four groups

	SIAS0		SIAS1–5		SIAS6–10		SIAS11–15	
	PT6 unit Group	PT3 unit Group	PT6 unit Group	PT3 unit Group	PT6 unit Group	PT3 unit Group	PT6 unit Group	PT3 unit Group
Number of patients	11	6	30	33	35	26	10	30
Age (years)	60.7±9.1*	76.3±7.4	62.5±12.2	67.0±9.2	69.1±12.8	68.0±11.2	62.7±11.3	68.0±13.0
Gender (Male, Female)	5, 6	3, 3	17, 13	22, 11	16, 19	15, 10	9, 1	15, 15
Diagnosis (Hemorrhage, Infarction)	6, 5	4, 2	16, 14	16, 17	12, 23	12, 13	9, 1	16, 14
Paralytic side (Right, Left)	2, 9	0, 6	7, 23	9, 24	14, 21	9, 16	3, 7	9, 21
Time after onset (days)	33.9±11.0	31.7±8.2	31.5±12.8	37.7±12.5	29.2±11.4	36.4±13.7	31.2±9.0	31.0±11.7
Number of days spent in ward (days)	87.8±17.1	88.8±21.2	81.5±20.2	83.0±17.0	66.9±18.2	64.0±22.4	49.2±16.1	54.0±19.5
Gain of FIMW score	3.0±0.6*	2.3±1.2	2.9±0.9*	2.2±1.1	2.1±0.8	1.8±1.1	2.0±0.7	1.7±1.1

*$p < 0.05$

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