



Original Article

## Effective physical therapy activities to improve the supine-to-seated transfer time in stroke patients: an observational pilot study

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**Abstract.** [Purpose] This study aimed to examine the effective time allocation for physical therapy activities in patients with stroke. The primary outcome measure was the improvement in the time required to transition from the supine to the sitting position. [Participants and Methods] This study enrolled 19 inpatients with stroke. The activities performed during physical therapy were classified as nontherapeutic activities, minimal therapeutic activities, moderate therapeutic activities, high therapeutic activities, and other activities. We determined the relationship between the activities and the relative shortening ratio of the time required to sit up from the supine position for up to 13 weeks of physical therapy. We also considered the following background factors: patient information, functional independence measure, and Brunnstrom recovery stage. [Results] The Brunnstrom recovery stage for the lower extremity was identified as the confounding factor, and the participants were stratified into the Brunnstrom recovery stage 6 group, in which moderate therapeutic activities and other activities were significantly related to the relative shortening ratio. [Conclusion] The results suggested that other activities exerted a similar effect as moderate therapeutic activities in the Brunnstrom recovery stage 6 group and were more effective than high therapeutic activities in reducing the time required to sit up from the supine position.

**Key words:** Physical therapy, Stroke, Sit up

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### INTRODUCTION

In addition to conventional therapy program based on the Bobath concept<sup>1)</sup>, proprioceptive neuromuscular facilitation<sup>2)</sup>, and cognitive nerve rehabilitation<sup>3)</sup>, researchers have recently tested and explained the effects of other physical therapy sessions, such as walking assistance, functional electrical stimulation, and group circuit training<sup>4-7)</sup> in the rehabilitation of patients with stroke. Furthermore, a cumulative meta-analysis of the duration of stroke physical therapy suggests that an adequate physical therapy performed within 6 months following the onset of stroke exerts an effect on activities of daily living<sup>8)</sup>.

However, the effects of physical therapy as a routine medical treatment, different from research interventions, have not been extensively examined<sup>9-11)</sup>. The aforementioned research gap can be attributed to the various components of stroke physical therapy<sup>12, 13)</sup> decided by each facility or physical therapist and the different endpoints based on the specific research purpose<sup>14)</sup>. Moreover, interventions other than physical therapy, such as occupational therapy, simple therapy by a nurse or an attendant's family<sup>15)</sup>, voluntary training<sup>16)</sup>, and group rehabilitation<sup>17)</sup>, are often performed concomitantly with physical therapy. Furthermore, the evaluation of the effects of physical therapy is often entrusted to each facility or is based on

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the subjective judgement of each physical therapist. Hence, it is difficult to exclusively determine the effects of physical therapy on patient outcomes, and physical therapy is often downplayed by being labelled as the “Black Box” of rehabilitation interventions<sup>13, 18</sup>).

To address these issues, the present study aimed to evaluate the effects of physical therapy as a usual medical treatment during stroke rehabilitation. This necessitated classifying a complex physical therapy program into several categories and evaluating the effect of each category. Second, it was necessary to set up a simplified endpoint that could be measured uniformly in any facility; thus, we chose the supine-to-sitting transfer time, which is a daily activity for stroke patients. This study endpoint was defined as the time difference ratio required by stroke patients to sit up from the supine position on a bed before and after physical therapy. To achieve its aim, this study is required to address two key issues: the selection of confounding factors associated with outcomes and activities in physical therapy and the identification of important factors affecting the study outcomes. Moreover, this study aimed to serve as a pilot study for a future multicenter, prospective observational study to explore the effects of physical therapy on the abovementioned ratio.

## PARTICIPANTS AND METHODS

This was a prospective observational single-center study. The study participants were stroke patients who had been hospitalized in the St. Mary’s Healthcare Center in Kurume City, Fukuoka Prefecture, Japan, from October 2019 to March 2020.

The inclusion criteria included the following: inpatients who were receiving physical therapy care at the time of the study and diagnosed with cerebral hemorrhage or cerebral infarction presenting with hemiplegia. The exclusion criteria included the following: patients with any risks associated with sitting up from the supine position, those suffering with other diseases that may make it difficult to sit up from the static supine position, difficulty in movement (pain) or psychogenic illness, and difficulty comprehending movement because of severe dementia.

Patient demographic data for age, gender, days after stroke onset, hemorrhage, infarction, affected limb, and dominant hand paralysis were obtained from medical records. The assessment point before the physical therapy intervention was termed “pre-PT” and that after the intervention was termed “post-PT”. The period between “pre-PT” and “post-PT” was set to a maximum of 13 weeks.

To explore the effect of usual physical therapy on the outcome, we classified the various components that physical therapists can recognize in their sessions<sup>19</sup>. The activity-focused physical therapy was classified into the following five categories with some modifications from previous studies<sup>9, 20</sup>, and the classification was collectively termed as the activity performed during physical therapy (AP): nontherapeutic activity (AP0), nonphysical therapy treatment such as a medical interview and physical therapy assessment; minimal therapeutic activity (AP1), activity in a static posture such as joint exercise, stretching exercise, and muscle strengthening; moderate therapeutic activity (AP2), activity in dynamic posture such as sitting balance and activity of daily living including roll-over and transition from the supine to sitting position; high therapeutic activity (AP3), standing, walking, or climbing stairs without a special equipment; and other activity (AP4), activity with special equipment such as electrotherapy, cycle ergometer, and tilt table. The ratio of AP items during the observation period was recorded by the physical therapist, and the AP item time of each participant was calculated from the total time of physical therapy. Physical therapists logged therapy minutes and the percentage of the time spent on each AP. Recording of the AP rate in this way has been shown to have good accuracy<sup>9, 19</sup>. The following parameters were measured pre-and post-PT: Brunnstrom recovery stage (BRS), functional independence measure (FIM), and the time required to sit up from the supine position (TSS). Apart from physical therapy, data on other interventions/factors were also recorded. These included occupational therapy time, whether training was provided by a nurse or caregiver, and the presence or absence of voluntary training. In addition, the years of experience of the physical therapist or that of the primary person in charge, if there were multiple physical therapists, was also recorded.

The participants who could independently sit up from the supine position were assigned to “the independent group”, and those who required assistance were assigned to “the dependent group”. In the independent group, the participants were instructed to move at a comfortable speed, as the TSS was recorded. The size of the examination table used to evaluate the movement was 200 and 120 cm in length and width, respectively, and the height was 45 or 50 cm based on the participant. Aids, such as handrails, could not be used, and the use of pillows was optional. Unless mentioned otherwise, participants started from an initial supine position, with arms extended on their sides, hips adducted, legs extended, and feet together. The motion began at the start signal of the evaluator, and the end of the measurement was when the participant had achieved a comfortable sitting position. The TSS at pre-and post-PT was recorded in triplicate using a stopwatch, and the average value was defined as representative value of the TSS<sup>21</sup>. The same evaluator performed the evaluation at both points, and these evaluations were conducted in a similar environment. The measurement of the time required for the transfer had previously been verified for its intra-rater and inter-rater reliability<sup>21, 22</sup>).

In this study, we set the relative shortening ratio (RSR) as the endpoint. The RSR was defined as the value obtained by subtracting the post-PT TSS from the pre-PT TSS and dividing it by the pre-PT TSS. The following equation was used to determine RSR:

$$RSR = (TSS \text{ of pre-PT} - TSS \text{ of post-PT}) \div (TSS \text{ of pre-PT})$$

A linear regression model was developed using the RSR and FIM motor score difference data from the independent group:

$$y=0.103+0.011x \quad (y=\text{RSR}, x=\text{FIM motor score difference})$$

The FIM motor score difference was obtained by subtracting the pre-PT from post-PT values. While the RSR of the independent group was the objective variable, the FIM motor score difference was the explanatory variable. Next, the estimated RSR value of the dependent group was calculated by substituting the dependent group's FIM motor score difference in the model and used as the RSR of the dependent group. We calculated the estimated RSR value by using the FIM motor score difference of the dependent group.

The confounding factor biases the relationship between the AP and RSR and is related to both the AP and RSR. The total time of AP1, AP2, AP3, and AP4, excluding AP0, which are not primarily related to the spontaneous exercise, were defined as the index of AP, the "AP-time". The factors that were significantly related to both AP-time and RSR was selected as the confounding factor, at a significance level of 20% for variable selection.

Fisher's exact test or the Wilcoxon rank-sum test was performed to compare the two groups, as appropriate. The association between continuous variables was determined from single regression analysis. A multivariate analysis was performed adjusted for the confounding factor, with the RSR and AP1, AP2, AP3, and AP4 as the objective and explanatory variables. The statistical software R 4.0.2 was used for all analyses, and the significance level was set at 5%.

This study was approved by the Ethics Committee (Approval number: 31-009) of Kyushu University of Nursing and Social Welfare and the Research Ethics Review Committee (Approval number: 19-0812) of St. Mary's Healthcare Center, and written informed consent was obtained from all participants before participant enrollment in the study.

## RESULTS

Although 20 participants met the inclusion criteria, one participant wished to be discharged early and was, therefore, excluded; hence, a total of 19 participants were included in this study. Table 1 summarizes the background of the study participants. The participants included 10 males and 9 females, with an average age of 69.0 years. Table 2 summarizes the results of BRS, FIM, and TSS, before and after PT. The pre-and post-PT FIM motor scores were  $64.4 \pm 24.5$  and  $81.1 \pm 16.3$ , respectively. The pre-and post-PT TSS were  $4.2 \pm 3.1$  s and  $2.8 \pm 1.8$  s, respectively, in the independent group. Table 3 summarizes RSR, the average time and standard deviation of AP and occupational therapy, whether therapy was delivered by a nurse or caregiver, the presence or absence of voluntary training, and the years of experience of the physical therapist, divided into two values, namely "<5 years" and "≥5 years". The average time of AP1, AP2, AP3 and AP4, excluding AP0 which was not related to physical therapy, was 16.4, 8.2, 22.7, and 5.3 h, respectively. These are the estimated times calculated from the AP percentage records.

We conducted a linear regression or two-group comparison test to identify variables associated with RSR and AP-time. Six variables were selected at the 20% significance level: BRS lower extremity at pre-PT (BRS-LE), upper extremity at pre-PT (BRS-UE), pre-PT FIM motor, years of experience of physical therapist, occupational therapy and voluntary training. Table 4 shows the relationship between the six variables. We chose BRS-LE as the representative confounding factor and stratified the participants by this variable. Participants with BRS-LE stage 6 were classified as the "BRS-6 group", and multivariate analysis was conducted with variables AP1, AP2, AP3, and AP4 as explanatory variables (Table 5). Explanatory variables in the BRS-6 group displayed a significant association with the RSR at a 5% significance level: AP2 ( $p=0.049$ ) and AP4 ( $p=0.048$ ).

**Table 1.** Participants' characteristics

Age (years), mean (SD)	69.0 (14.0)
Gender, n, male/female	10/9
Days after onset, mean (SD)	31.4 (8.6)
Hemorrhage, n (%)	9 (47.4)
Infarction, n (%)	10 (52.6)
Affected limb, right /left	17/2
Dominant hand paralysis, n (%)	8 (42.1)
Independently sit up from the supine position, n (%)	16 (84.2)

SD: standard deviation.

**Table 2.** Evaluation results in pre-PT and post-PT

	pre-PT	post-PT	
Brunnstrom recovery stages, number of stage 6, n (%)			
Upper extremity	12 (63.2)	14 (73.7)	
Lower extremity	15 (78.9)	15 (78.9)	
Hand	13 (68.4)	15 (78.9)	
FIM, mean (SD)			
Motor	64.4 (24.5)	81.1 (16.3)	*
Cognition	28.4 (8.0)	30.5 (6.9)	
TSS, sec, mean (SD)	4.2 (3.1)	2.8 (1.8)	*

\*p-value of <0.05, calculated by using Fisher's exact test and Wilcoxon rank-sum test. FIM: functional independence measure; TSS: the time required to sit up from the supine position in the independent group (n=16); SD: standard deviation.

**Table 3.** Relative shortening ratio (RSR) and interventions

RSR, (95% confidence interval)	0.28 (0.17–0.39)
The time of AP, h, mean (SD)	
AP0	7.4 (5.5)
AP1	16.4 (17.8)
AP2	8.2 (7.5)
AP3	22.7 (12.8)
AP4	5.3 (5.4)
Total	59.9 (29.3)
Occupational therapy time, h, mean (SD)	48.7 (27.8)
Therapy by a nurse or a caregiver, Present/Absent	4/15
Voluntary training, Present/Absent	13/6
Physical therapist experience years, <5 years/≥5 years	12/7

RSR: relative shortening ratio; AP: activity performed during physical therapy; SD: standard deviation; time: an estimated time calculated from the physical therapist's records.

**Table 4.** Relationships between study variables that are relevant to both relative shortening ratio (RSR) and activity performed during physical therapy (AP)

	pre-BRS-LE	pre-FIM	PT years	OT	VT
pre-BRS-UE	*	*			
pre-BRS-LE		*			
pre-FIM					*
PT years				*	*
OT					*

\*p-value of <0.05: calculated using simple linear regression analysis, Fisher's exact test, the Wilcoxon rank-sum test. pre-BRS-LE: BRS lower extremity at pre-PT; pre-BRS-UE: BRS upper extremity at pre-PT; pre-FIM: FIM motor score at pre-PT; OT: Occupational therapy time; VT: The presence of voluntary training.

**Table 5.** Multivariate analysis results for the BRS-6 group (n=15)

	Estimate	SE	95% confidence interval	
Intercept	-0.030	0.133	-0.327–0.267	
AP1	0.004	0.003	-0.003–0.012	
AP2	0.022	0.010	0.000–0.045	*
AP3	-0.002	0.005	-0.012–0.009	
AP4	0.022	0.010	0.000–0.043	*

\*p-value of <0.05, SE: standard error.

## DISCUSSION

This is a pilot study, conducted to precede a multicenter study targeting inpatients with stroke in the convalescent wards in Japan, which aimed to explore the effectiveness of physical therapy as a routine medical treatment in clinical practice. In this study, we attempted exploratory validation at a single institution by focusing on the activities performed during physical therapy, attempting to classify them, and establishing endpoints that are easy to measure.

In non-randomized observational studies, confounding factors strongly influence the results<sup>23, 24</sup>. The association between an activity in usual physical therapy and sitting up from the supine position has been reported to be strongly influenced by confounding factors, such as background factors and other interventions. This study focused on selecting confounding factors, and it excluded their effects by stratification<sup>25</sup>. The level of significance was set at 20% to allow many confounding factors to be identified to generate more conservative results<sup>26</sup>. We selected six variables as a confounding factor. The pre-PT BRS-LE, BRS-UE and FIM motor score were highly related to each other, and the BRS-LE indicated a weak association between other variables. The previous study has stated that sitting up from the supine position in patients with stroke is

strongly related to standing balance and gait<sup>27</sup>). We identified the BRS-LE as the representative value of confounding factors considering the relationship among variables and clinical importance, and conducted a stratified analysis on that variable. In other words, by adjusting for the severity of the patient's symptoms, we can make an appropriate assessment. This, in turn, could help in the evaluation of the effects of physical therapy routinely performed for patients with stroke. Nonetheless, the selection of other factors or some combination of factors could produce similar results<sup>28</sup>).

Although there were only 15 participants in the BRS-6 group, activities such as roll-over and transition from the supine to sitting position, and activities with special equipment such as electrotherapy, cycle ergometer, or tilt table were found to be significantly related to the RSR. This can be attributed to the adjustment for the confounding factor. However, there was no statistically significant effect on AP3. This study shows that activities such as roll-over and transition from supine to sitting position and an activity with special equipment can be more effective for the RSR than activities such as standing and walking, including balance exercises and climbing stairs. This pilot study was focused on the time required for sitting up from the supine position, but the results would have been different if the endpoint was measured for standing or walking. By allocating the time for gait practice, which is generally long in usual physical therapy<sup>29</sup>), to AP2, it is expected that TSS will improve. Thus, we suggest that the TSS could be improved by categorizing the highly complex component of physical therapy by focusing on the activities being performed and adjusting the time distribution of these activities.

There are some limitations to this study. In this study, we selected the lower extremities for BRS as a confounding factor and validated only the BRS-6 group. However, as the sample size increases, the relationship with other stages is expected to become clearer. To clarify the effects of physical therapy, the study design should assume that there are many confounding factors, such as other interventions implemented along with physical therapy including occupational therapy, self-directed training, family support, training by nurses and caregivers, and physician guidance. In this study, we focused on only the frequency of other interventions and did not conduct detailed investigations of other interventions, including overall time and category. It can be assumed that a comparative study stratified into groups, with and without other interventions, will reveal more about the effects of physical therapy activities. This would require a randomized controlled trial, and a larger number of cases would be desirable.

The novel finding of this study was that those activities with special equipment, such as electrotherapy, cycle ergometer, and tilt table, were significantly related to the RSR. It would be of interest to further investigate the type of physical therapy and equipment effective for RSR. Nonetheless, it is difficult to obtain comprehensive results in a pilot study. Therefore, its conclusion will be clarified in a larger multicenter collaborative study.

To accurately assess the effectiveness of physical therapy to reduce the time taken to sit up from the supine position, the severity of the patient needs has to be adjusted for. In addition, despite being a pilot study, the activities including sitting up from the supine position and other therapies that require the use of special equipment, such as electrotherapy, cycle ergometer, and tilt table, were found to be significantly related to the shortening of the TSS in the BRS-6 group.

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### *Conflict of interest*

There are no conflicts of interest to declare.

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