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Original Article

Changes in physical activity level during hospitalization in patients with stroke and those with fracture: a prospective longitudinal study

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Abstract. [Purpose] To examine changes in physical activity levels between admission and discharge in patients hospitalized after stroke and fracture. [Participants and Methods] Patients with stroke (n=36) or fracture (n=41) wore an accelerometer during the daytime for three days after admission and before discharge. Physical activity was divided into sedentary behavior (SB), light-intensity (LIPA), and moderate-to-vigorous (MVPA), and then compared between hospital admission and discharge using the Wilcoxon signed-rank test. The characteristics of patients with or without changes in SB during hospitalization were compared using the Mann–Whitney *U* test. [Results] The median LIPA time in patients after stroke and fracture increased from 107.5 and 106.7 minutes on admission to 122.0 and 127.3 minutes at discharge, and the median MVPA time increased from 2.7 and 0.7 minutes on admission to 4.2 and 2.7 minutes at discharge, respectively. In particular, LIPA in non-therapy time increased for patients both after stroke and fracture. No differences in characteristics were observed between with or without changes in SB regardless of differences in diagnoses. [Conclusion] These findings indicate that while physical activity levels increased during hospitalization, they remained below World Health Organization recommendations for MVPA, and patient characteristics alone may not account for increased activity levels.
Key words: Inpatient, Physical activity, Rehabilitation

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INTRODUCTION

Increasing physical activity levels has been shown to have positive effects in older adults (e.g., improvements in physical function, cognition, and risk of all-cause mortality)[1)]. Particularly for cerebrovascular disease, increased physical activity is reportedly effective for reducing the risks of stroke[2)], less-severe stroke[3)], all-cause mortality[4)], and stroke recurrence[5)]. Regarding musculoskeletal problems such as falls and fractures, increased physical activity has also been found to be effective for lowering the risks of falls and fall-related injuries[1)], improving bone health[1)], and reducing the risk of re-fracture[6)]. Increased physical activity is therefore important for older adults with stroke and musculoskeletal disease.

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While increasing physical activity is important, activity levels are generally low among individuals with chronic illnesses[7, 8]. Moreover, according to a systematic review[9], inpatients with stroke or after orthopedic surgery spend 93%–98.8% of their hospital stay in a sedentary state. Both patients with stroke and those with fracture show increased physical activity as uptime (i.e., time spent upright and walking) during the transition from hospital to home[10, 11]. However, few reports have examined changes in physical activity levels during hospitalization, and some studies have reported divergent results, with increased activity in some and no change in others[11–14]. In addition, whether any actual changes in physical activity occur during therapy or non-therapy time remains unclear.

Furthermore, the leisure-time physical activities of older adults with chronic diseases (e.g., musculoskeletal disease, vascular heart disease, stroke) are similar, with most walking, gardening, or performing exercises at home[15]. Conversely, older adults with stroke are more inactive than other individuals with chronic disease in community settings[15]. However, because of the differences in the environment between community and hospital settings, whether there is a similar difference between stroke and others remains unclear, and to our knowledge, no studies have compared these patient groups. In particular, in Japan, both patients with stroke and those with fracture are admitted to convalescent rehabilitation units and treated by the same rehabilitation team. Therefore, clarifying whether differences in physical activity levels during hospitalization exist between these patients is important to encourage changes in behavior.

The doubly labeled water method is the gold standard for measuring physical activity, but it is difficult to perform in clinical practice for many reasons (e.g., cost, time-intensiveness, high subject burden, etc.)[16]. Other studies measuring physical activity have used self-report questionnaires, direct observation, and accelerometers[16, 17]. Among these tools, accelerometers offer high accuracy, allow easy, objective measurement of movement, and measurements can be translated into energy expenditure units (e.g., kilocalories or metabolic equivalents [METs]) or activity intensity categories. In particular, the World Health Organization (WHO) recommends that all adults, including those with chronic conditions, engage in 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity physical activity each week, or a combination of both[18]. Moreover, recommendations regarding physical activity and sedentary behavior (SB) among older adults during hospitalization include aiming to accumulate regular physical activity and minimizing long periods of uninterrupted SB during waking hours[19]. Therefore, objective measurements of physical activity in terms of intensity are important.

In addition, objective identification of changes in physical activity levels and differences in diagnoses during hospitalization is important for promoting optimal physical activity during hospitalization. In this study, we hypothesized that: 1) physical activity would increase during non-therapy time with improvements in physical function; and 2) patients with stroke would show less change in activity than those with fracture because patients with stroke are inactive even before the onset of stroke. Given this background, the present study aimed to identify whether physical activity changes during the period from admission to discharge within a population of hospitalized patients and to compare trends between patients with stroke and those with fracture.

PARTICIPANTS AND METHODS

This prospective longitudinal observational study was conducted in the convalescent rehabilitation unit of a public hospital in Japan. Patients admitted from March 2021 to August 2022 were followed until discharge. The present study applied the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement[20].

Patients were recruited from the convalescent rehabilitation unit of Nanokaichi Hospital, a public hospital. This hospital has 162 beds, 57 of which are in the convalescent rehabilitation unit, where intensive daily rehabilitation is provided to patients who have completed acute treatment, such as after stroke, hip fracture, and vertebral fracture. All patients were admitted to the convalescent rehabilitation unit directly from an acute care hospital after stabilizing treatment.

The inclusion criteria were as follows: 1) admission with stroke or fracture (lower extremity, pelvis, or vertebra); and 2) ability to manage an accelerometer during the day. The exclusion criteria were: 1) an unstable condition requiring medical treatment; 2) complications or a past history affecting ambulation; and 3) hospital discharge within 1 week of admission.

This study was approved by the Ethics Review Committee of Nanokaichi Public Hospital (approval No. 20200120) and registered with the University Hospital Medical Information Network Clinical Trials Registry (UMIN000050278). All participants provided verbal and written informed consent before data collection began.

The following demographic data were collected from medical records at hospitalization: sex, age, body mass index, affected side, days from onset or surgery to hospitalization, first-ever or recurrent stroke, and history of fracture. Walking ability before onset was assessed using the Functional Ambulation Classification of the Hospital at Sagunto (FACHS). The FACHS is a 6-point classification scale ranging from 0 (non-ambulation) to 5 (normal ambulation)[21]. The FACHS before onset was assessed based on the results of interviews conducted by the corresponding author at the beginning of physical activity measurement. The following measures of physical ability and cognitive function were assessed on admission to and discharge from the hospital: the Mini-Mental State Examination (MMSE)[22], Brunnstrom recovery stage (BRS) of the affected lower limb[23], Berg Balance Scale (BBS)[24], Functional Ambulation Category (FAC)[25], use of a walking aid, modified Gait Efficacy Scale (mGES)[26], and Functional Independence Measure[27]. BRS of the lower limb was assessed only in patients with stroke.

Physical activity was measured using the Active Style Pro HJA-750C (ASP-750C) physical activity monitor with a triaxial accelerometer (OMRON, Kyoto, Japan). The ASP-750C is a small, lightweight activity monitor (52 mm × 40 mm × 12 mm; 23 g) that uses the same algorithm as the previous model, the Active Style Pro HJA-350IT. These algorithms can estimate METs with high accuracy[28–31].

The first measurement was made between 1 and 3 weeks after hospital admission and the second within 2 weeks until discharge. Measurements by accelerometer were conducted every 3 weekdays except weekends (the period from the start to the end of measurement was 4.2 ± 2.2 days). The physical activity monitor was attached to the waist of the patient before 08:30 and removed after 17:00 each day by the researcher. Patients with stroke or after fracture of a lower extremity or pelvis wore the activity monitor on the non-affected side[32], whereas patients after vertebral fracture wore it on the right side. Other than therapy, no additional interventions, such as physical activity feedback or encouragement, were provided.

Activity intensity ≤1.5 METs was defined as SB[33], 1.6–2.9 METs as light-intensity physical activity (LIPA)[34], and ≥3 METs as moderate-to-vigorous physical activity (MVPA)[34]. Examples of activity intensity include SB is maintained posture such as lying, sitting, and standing, LIPA is sitting and standing with reaching task, and slow walking, MVPA is fast walking[31].

The duration of physical activity was calculated for daytime (08:31 to 17:00), therapy time, and non-therapy time. Therapy time was defined as the total time spent in physical therapy, occupational therapy, and speech language therapy, with each therapy time identified from the electronic medical records. Non-therapy time was defined as the daytime minus therapy time.

ASP-750C software (activity tracker application version 2.2; OMRON, Kyoto, Japan) was used to download the ASP-750C data. This software can extract activity intensity (in METs) for every 60-second epoch and output the data in Excel. Physical activity data from 08:31 to 17:00 were used. Patients were asked to record their bathing times, and the relevant non-wearing time data in the file were visually checked by the research staff and excluded from analysis.

The patients' characteristics are shown as the mean (standard deviation [SD]) or median (1st quartile [Q1] to 3rd quartile [Q3]) for continuous and ordinal variables, and as count (percentage) for categorical variables. The normality of variables was assessed using the Shapiro–Wilk test. Continuous variables showing normal distributions were compared using Student's *t*-test, whereas those with non-normal distributions were compared using the Mann–Whitney *U* test. Ordinal and categorical variables were tested using the χ^2 test and Fisher's exact probability test.

Comparisons of physical activity between hospital admission and discharge are shown as median (Q1 to Q3) and were tested using the Wilcoxon signed-rank test. Because walking independence may influence changes in physical activity, subgroup analysis was conducted separately for patients capable of independent walking. The effect size (r) of physical activity was calculated using data collected shortly after admission and in the pre-discharge period as defined above using the following equation: [$r=z / \sqrt{n}$]. Values of 0.1, 0.3, and 0.5 for the effect size (r) were interpreted as small, moderate, and large, respectively.

To compare patient characteristics according to changes in physical activity, patients were divided into those with decreased SB time (SB at discharge <SB on admission) and those with increased or unchanged SB time (SB at discharge≥SB on admission). Continuous variables showing a normal distribution were tested using Student's *t*-test, whereas those with non-normal distributions were tested using the Mann–Whitney *U* test. Ordinal and categorical variables were tested using the χ^2 test and Fisher's exact probability test.

Statistical analyses were performed using SPSS version 27.0 (SPSS, Chicago, IL, USA), with the exception of Fisher's exact probability test, which was only performed using JMP Pro version 15.2 (JMP Statistical Software; SAS Institute, Cary, NC, USA). The threshold for statistical significance in all experiments was set at $p<0.05$.

When the effect size was set to large (r=0.5), α error probability to 0.05, and 1-β error probability to 0.8, power calculations required 35 patients to detect longitudinal changes between hospital admission and discharge. A minimum of 35 patients each was thus required for patients with stroke and those with fracture. All sample size calculations were performed using G*power (Universität Düsseldorf, Düsseldorf, Germany).

RESULTS

A total of 337 patients were admitted to the hospital during the recruitment period. Among these patients, 163 were eligible for inclusion (Fig. 1), of whom 77 (36 with stroke, 41 with fracture) participated in this study. The characteristics of the patients are shown in Table 1. Patients with stroke were significantly more likely to be males, have a higher FACHS before onset, a higher BBS score, a higher mGES score, and a lower MMSE score than patients with fracture on admission. Both on admission and at discharge, the use of walking aids differed significantly between patients with stroke and those with fracture.

Changes in physical activity levels from admission to discharge are summarized in Table 2. For patients with stroke, the median SB time decreased significantly, from 398.5 to 381.8 minutes, mostly in therapy time. Both the median LIPA and MVPA times increased significantly, from 107.5 to 122.0 minutes and from 2.7 to 4.2 minutes, respectively, mostly in non-therapy time. For patients with fracture, the median SB time decreased significantly, from 402.3 to 375.3 minutes, mostly in therapy time. The median LIPA and MVPA times increased significantly, from 106.7 to 127.3 minutes and from 0.7 to 2.7 minutes, respectively, mostly in non-therapy time. The effect sizes for SB and MVPA time were moderate for patients with stroke, but large for patients with fracture.

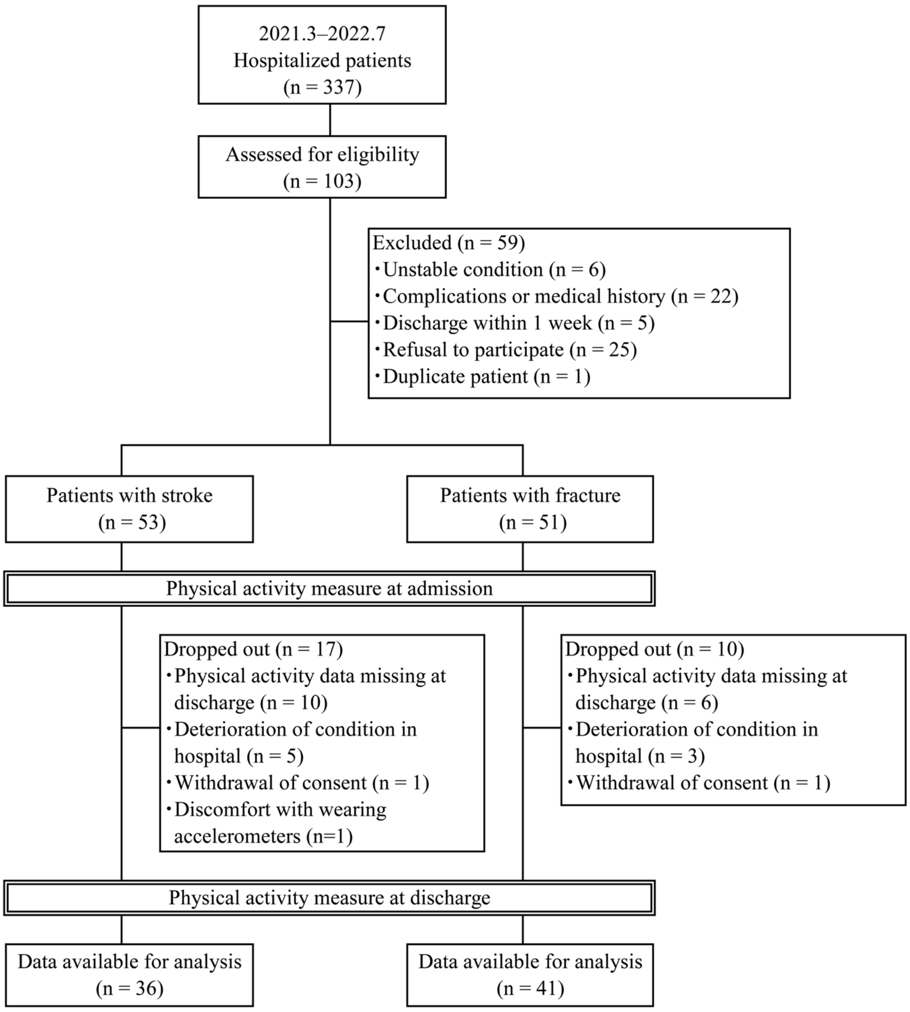

Fig. 1. Participant flow in the study.

Subgroup analysis was conducted separately for patients with and without the ability to walk independently (Fig. 2 and Table 3). Because few patients showed dependent walking (FAC ≤3) both on admission and at discharge (three patients with stroke, six patients with fracture), subgroup analysis was conducted for the following two groups: those with independent walking from admission, and those with dependent walking on admission, but independent walking at discharge (Fig. 2). For patients with dependent walking on admission who achieved independent walking by discharge, both patients with stroke and those with fracture showed significantly decreased SB and increased LIPA times. The LIPA time was significantly increased in non-therapy time, but unchanged in therapy time. For patients with independent walking on admission, both patients with stroke and those with fracture significantly increased MVPA times, but LIPA times remained basically unchanged, except for in non-therapy time among patient with fracture.

Table 4 shows the results of a comparison of patient characteristics by group (decreased vs. non-decreased SB time at discharge). In total, 56 patients (24 with stroke and 32 with fracture) showed decreased SB time, and 21 (12 with stroke and nine with fracture) showed non-decreased (i.e., increased or unchanged) SB time. Patients with decreased SB time showed an average decrease of 42.7 (SD 37.1) minutes. By contrast, the patient group with non-decreased SB time showed an average increase of 16.9 (SD 15.3) minutes. No significant differences in characteristics were observed between patients with stroke and those with fracture regardless of changes in SB.

DISCUSSION

This study obtained three major findings. First, most patients with stroke and those with fracture showed decreased SB time and increased activity time at discharge compared with admission to the rehabilitation unit. Most of the increase in activity time was seen in non-therapy time rather than in therapy time. Second, when improving from dependent to independent

Table 1. Demographic and medical characteristics of the patients with stroke and those with fracture in the present study

	Patients with stroke (n=36)		Patients with fracture (n=41)		Stroke vs. fracture p-value	
	Admission	Discharge	Admission	Discharge	Admission	Discharge
Male, n (%)	26 (72.2)		6 (18.9)		**	
Age (years), mean (SD)	75.4 (11.3)		78.8 (8.8)			
BMI (kg/m^2), mean (SD)	22.5 (4.0)		22.0 (4.1)			
Affected side (right/left/spine)	19/17/-		22/9/10		**	
Days from onset or surgery to hospitalization, median [Q1–Q3]	18.0 [14.0–23.8]		19.0 [14.0–25.5]			
Days from onset or surgery to start of wearing accelerometer, median [Q1–Q3]	26.0 [22.0–31.8]		27.0 [22.0–35.5]			
Days from admission to start of wearing accelerometer, median [Q1–Q3]	8.0 [7.0–10.0]		8.0 [7.0–10.0]			
Length of hospital stay (days), median [Q1–Q3]	60.5 [34.3–88.3]		53.0 [40.0–73.5]			
Recurrent stroke, n (%)	7 (19.4)		-		-	
Re-fracture, n (%)	-		18 (43.9)		-	
FACHS before onset (0/1/2/3/4/5)	0/1/0/4/7/24		0/0/4/13/11/13		**	
MMSE (points), median [Q1–Q3]	24.5 [22.0–28.0]	26.0 [23.0–28.0]	27.0 [24.0–28.5]	27.0 [25.0–29.0]	*	
Brunnstrom recovery stage of lower limb (I/II/III/IV/V/VI)	0/1/2/2/14/17	0/0/1/2/11/22	-	-	-	-
BBS (points), median [Q1–Q3]	47.5 [35.0–53.0]	53.0 [47.3–55.8]	37.0 [22.5–43.5]	52.0 [47.0–55.0]	**	
FAC (0/1/2/3/4/5)	5/3/2/8/13/5	2/0/2/1/13/18	7/1/1/17/14/1	1/0/0/5/17/18		
Walking aids (parallel bars/walker/cane/none)	7/3/5/21	2/2/6/26	7/24/7/3	1/11/11/18	**	*
mGES (points), median [Q1–Q3]	52.5 [37.3–65.5]	72.5 [57.0–87.3]	33.0 [20.0–52.0]	64.0 [48.0–74.0]	**	
FIM (points), median [Q1–Q3]	99.0 [80.5–115.8]	112.0 [102.3–119.3]	98.0 [82.5–110.0]	112.0 [102.0–118.0]		

*p<0.05; **p<0.01.
SD: standard deviation; BMI: body mass index; Q1: 1st quartile; Q3: 3rd quartile; FACHS: Functional Ambulation Classification of the Hospital at Sagunto; MMSE: Mini-Mental State Examination; BBS: Berg Balance Scale; FAC: Functional Ambulation Category; mGES: modified Gait Efficacy Scale; FIM: Functional Independence Measure.

Table 2. Changes in physical activity levels between admission and discharge in patients with stroke and those with fracture

	Patients with stroke (n=36)				Patients with fracture (n=41)			
	Admission time	Discharge time	p-values	Effect size	Admission time	Discharge time	p-value	Effect size
Daytime, min								
SB time	398.5 [370.8–419.3]	381.8 [335.6–408.9]	**	0.48	402.3 [349.3–420.7]	375.3 [340.3–402.7]	**	0.61
LIPA time	107.5 [87.3–136.1]	122.0 [94.8–143.1]	*	0.37	106.7 [88.5–155.3]	127.3 [101.8–161.0]	**	0.47
MVPA time	2.7 [1.4–5.8]	4.2 [1.0–13.6]	**	0.45	0.7 [0.3–1.7]	2.7 [0.3–5.7]	**	0.53
Total time	510 [510–510]	510 [510–510]		0.13	510 [510–510]	510 [510–510]	*	0.37
Therapy time, min								
SB time	83.7 [65.3–104.8]	73.5 [54.3–86.5]	**	0.49	72.0 [46.7–84.0]	50.7 [38.0–63.5]	**	0.72
LIPA time	52.3 [43.4–64.0]	55.7 [42.6–69.6]		0.14	55.3 [44.5–68.3]	51.3 [39.5–63.2]	*	0.32
MVPA time	1.3 [0.4–2.6]	1.5 [0–6.4]	**	0.44	0.3 [0–1.5]	0.7 [0–2.2]	**	0.48
Total time	140.7 [121.4–152.5]	132.8 [113.4–151.1]	*	0.33	119.7 [111.3–138.3]	100.3 [92.8–120.0]	**	0.71
Non-therapy time, min								
SB time	318.8 [276.9–342.9]	305.7 [271.6–336.9]		0.24	332.3 [280.0–359.5]	316.3 [286.0–348.8]		0.26
LIPA time	53.3 [34.5–79.3]	61.5 [45.4–79.3]	*	0.36	49.3 [37.0–95.8]	74.3 [54.5–101.3]	**	0.67
MVPA time	1.2 [0.8–3.3]	2.3 [0.7–4.5]	**	0.44	0.7 [0.3–1.7]	1.3 [0.2–2.8]	**	0.42
Total time	368.2 [357.5–388.6]	377.2 [356.7–396.6]		0.29	390.0 [371.7–398.7]	409.7 [389.8–415.0]	**	0.63

*p<0.05; **p<0.01.
Values are expressed as medians [Q1–Q3].
SB: sedentary behavior; LIPA: light-intensity physical activity; MVPA: moderate-to-vigorous physical activity.

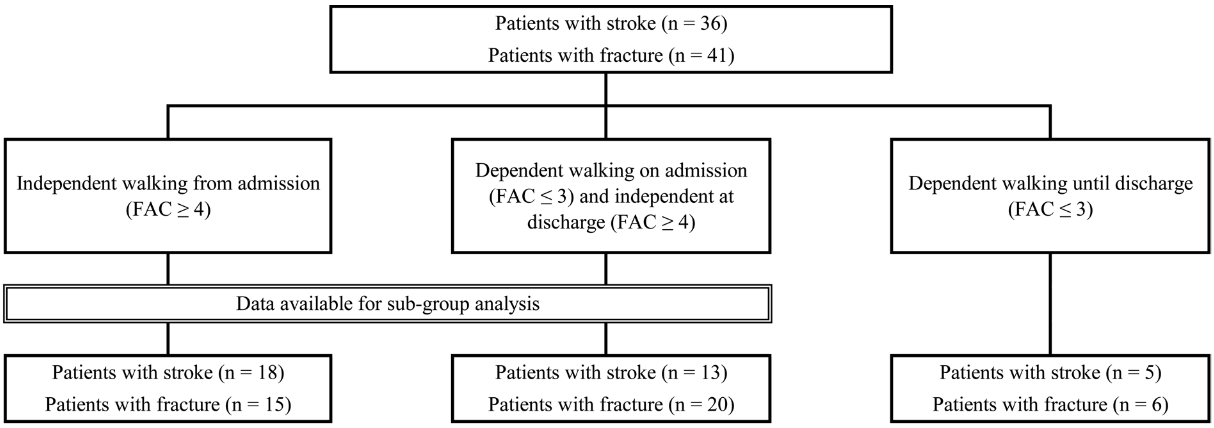

Fig. 2. Participant flow in sub-group analysis.
FAC: Functional Ambulation Category.

walking during hospitalization, many patients showed increased activity time, except those with independent walking on admission, in whom activity time was unchanged. Third, no significant differences in characteristics were observed between patients with stroke and those with fracture regardless of changes in SB.

In this study, LIPA and MVPA times were increased at discharge compared with on admission for both patients with stroke and those with fracture. These increases in activity time mainly occurred in non-therapy time. To our knowledge, this is the first study to examine changes in physical activity in both patients with stroke and those with fracture by dividing daytime into therapy and non-therapy times during hospitalization. Some studies have reported that patients display increased standing or walking time after stroke or fracture[11, 35], and the present study showed a similar trend. Because improvements in function allow increased physical activity[35], intensive rehabilitation during hospitalization may lead to decreases in SB and increased activity time during non-therapy time for patients with stroke and those with fracture. However, despite this increase in activity time, that for inpatients was clearly below the recommendations of the WHO[18], and thus, additional interventions are needed to increase activity.

Table 3. Changes in physical activity levels between admission and discharge separately for patients with independent and those with dependent walking

	Independent walking on admission and at discharge						Dependent walking on admission and independent at discharge					
	Patients with stroke (n=18)			Patients with fracture (n=15)			Patients with stroke (n=13)			Patients with fracture (n=20)		
	Admission time	Discharge time	p-value	Admission time	Discharge time	p-value	Admission time	Discharge time	p-value	Admission time	Discharge time	p-value
Daytime, min												
SB time	383.5 [332.6–407.9]	381.8 [316.5–404.3]		349.3 [323.7–384.7]	341.7 [278.0–381.3]	*	400.0 [390.8–427.0]	378.7 [321.2–389.5]	**	407.3 [387.5–421.0]	377.2 [355.8–404.4]	**
LIPA time	121.5 [95.3–164.2]	118.3 [94.7–146.1]		151.3 [123.3–183.3]	159.0 [112.3–228.3]		106.0 [82.2–117.7]	126.0 [118.5–175.3]	**	101.5 [88.8–122.2]	132.0 [105.5–151.1]	**
MVPA time	5.0 [2.9–8.1]	6.8 [3.2–26.4]	*	3.0 [0.7–5.3]	6.3 [2.7–17.7]	**	2.3 [0.8–3.2]	3.7 [0.5–12.3]		1.0 [0.4–1.7]	2.2 [0.4–4.1]	*
Total time	510 [510–510]	510 [510–510]		510 [510–510]	510 [504.7–510]	*	510 [510–510]	510 [510–510]		510 [510–510]	510 [510–510]	
Therapy time, min												
SB time	81.8 [62.3–96.8]	64.2 [50.4–77.3]	*	51.3 [35.0–75.7]	39.3 [30.0–62.7]		75.0 [63.0–104.3]	78.0 [54.2–84.3]		72.2 [55.2–84.2]	50.7 [42.8–62.8]	**
LIPA time	53.0 [44.3–63.4]	51.7 [42.5–72.8]		63.0 [52.7–75.0]	55.3 [49.7–77.7]		55.7 [45.2–64.8]	60.0 [53.5–66.0]		54.5 [51.2–60.0]	51.7 [42.8–59.0]	
MVPA time	1.8 [1.2–4.0]	3.5 [0.8–7.6]	*	2.0 [0–4.0]	2.0 [1.0–7.7]	*	1.0 [0.1–1.5]	0.3 [0–5.0]		0.3 [0–0.6]	0.5 [0–1.8]	*
Total time	139.3 [122.3–154.4]	128.0 [105.8–155.9]		117.7 [103.3–139.0]	112.0 [93.0–131.3]		140.0 [115.2–154.0]	138.3 [122.8–150.0]		126.0 [113.5–140.9]	100.0 [97.9–119.3]	**
Non-therapy time, min												
SB time	290.7 [269.3–320.4]	300.8 [260.0–342.3]		280.0 [269.7–345.3]	293.0 [226.0–344.3]		330.7 [314.8–356.3]	308.0 [231.8–326.0]	**	334.2 [304.1–354.4]	318.5 [298.2–349.8]	
LIPA time	69.5 [42.3–93.6]	55.0 [44.1–106.1]		93.7 [52.7–119.0]	90.7 [61.3–141.7]	*	47.3 [25.3–70.2]	64.0 [58.2–118.5]	**	43.8 [36.8–68.6]	76.7 [58.0–97.5]	**
MVPA time	3.0 [1.3–4.1]	3.5 [1.2–12.5]		1.0 [0.3–2.0]	2.7 [1.3–7.7]	*	1.0 [0.7–1.3]	2.3 [0.5–3.7]	*	0.7 [0.3–1.0]	1.2 [0.3–2.2]	
Total time	368.3 [355.6–387.8]	382.0 [354.1–404.3]		392.3 [371.0–406.7]	398.0 [365.0–417.0]		370.0 [356.0–394.8]	370.0 [360.0–387.2]		384.0 [369.1–396.5]	410.0 [390.7–411.8]	**

*$p<0.05$; **$p<0.01$.
Values are expressed as medians [Q1–Q3].
SB: sedentary behavior; LIPA: light-intensity physical activity; MVPA: moderate-to-vigorous physical activity.

Table 4. Comparison of patient characteristics according to changes in SB time

	Patients with stroke		Patients with fracture	
	Patients with reduced SB time (n=24)	Patients with increased or unchanged SB time (n=12)	Patients with decreased SB time (n=32)	Patients with increased or unchanged SB time (n=9)
Male, n (%)	19 (79.2)	7 (58.3)	4 (12.5)	2 (22.2)
Age (years), mean (SD)	73.3 (12.3)	79.5 (8.0)	78.3 (9.0)	80.6 (8.4)
BMI (kg/m^2), mean (SD)	22.8 (4.1)	21.8 (3.7)	21.7 (4.4)	22.9 (2.7)
Days from onset or surgery to hospitalization (days), median [Q1–Q3]	25.5 [22.0–31.0]	29.0 [23.0–34.5]	20.0 [15.5–26.5]	16.0 [12.0–25.0]
Length of hospital stay (days), median [Q1–Q3]	57.5 [38.5–88.5]	63.0 [32.5–87.5]	53.5 [44.5–73.8]	47.0 [34.0–61.0]
FACHS before onset (0/1/2/3/4/5)	0/0/0/3/5/16	0/1/0/1/2/8	0/0/3/12/7/10	0/0/1/1/4/3
On admission				
MMSE (points), median [Q1–Q3]	25.5 [22.0–27.5]	24.0 [21.5–28.0]	27.0 [24.0–28.0]	27.0 [25.0–30.0]
BBS (points), median [Q1–Q3]	46.0 [28.5–53.0]	49.0 [40.5–51.5]	36.5 [22.5–40.5]	43.0 [37.0–44.0]
FAC (0/1/2/3/4/5)	4/2/2/6/7/3	1/1/0/2/6/2	5/1/1/14/10/1	2/0/0/3/4/0
Walking aids (parallel bars/walker/cane/none)	5/2/4/13	2/1/1/8	5/21/3/3	2/3/4/0
mGES (points), median [Q1–Q3]	50.0 [28.5–61.5]	58.5 [48.0–71.0]	31.0 [20.0–47.0]	45.0 [32.0–57.0]
FIM (points), median [Q1–Q3]	94.5 [78.0–116.5]	107.0 [92.5–112.0]	97.5 [83.0–110.0]	98.0 [73.0–107.0]
At discharge				
MMSE (points), median [Q1–Q3]	26.0 [25.0–28.5]	25.0 [22.0–27.5]	27.0 [25.0–28.5]	27.0 [24.0–29.0]
BBS (points), median [Q1–Q3]	53.0 [48.5–55.0]	54.0 [48.5–56.0]	52.5 [47.0–55.0]	52.0 [48.0–53.0]
FAC (0/1/2/3/4/5)	1/0/1/1/9/12	1/0/1/0/4/6	0/0/0/4/14/14	1/0/0/1/3/4
Walking aids (parallel bars/walker/cane/none)	1/1/5/17	1/1/1/9	0/8/10/14	1/3/1/4
mGES (points), median [Q1–Q3]	72.0 [57.0–86.5]	73.0 [62.5–88.0]	62.0 [53.0–71.5]	73.0 [23.0–86.0]
FIM (points), median [Q1–Q3]	116.0 [103.0–121.0]	112.0 [99.5–113.0]	115.0 [103.0–118.0]	109.0 [94.0–114.0]

SB: sedentary behavior; SD: standard deviation; Q1: 1st quartile; Q3: 3rd quartile; BMI: body mass index; FACHS: Functional Ambulation Classification of the Hospital at Sagunto; MMSE: Mini-Mental State Examination; BBS: Berg Balance Scale; FAC: Functional Ambulation Category; mGES: modified Gait Efficacy Scale; FIM: Functional Independent Measure.

Patients showing dependent walking on admission and independent walking at discharge demonstrated increases in LIPA and MVPA, but no changes were seen in those who showed independent walking on admission. Some studies have reported that patients capable of independent walking achieve higher activity levels, including standing or walking time, number of steps, and activity intensity, compared with those with dependent walking[36–38]. Independent walking is a prerequisite for increasing activity levels. A previous study of acutely admitted patients found that person-assisted and bedridden patients increased their upright time per day during hospitalization, whereas independent patients showed an average decline of 4.5 minutes per day[39], similar to the present study. Most studies have reported that older adults with chronic disease after discharge show immediately increased activity time compared with during hospitalization[10–12]. The lack of patient activity may thus be related to the influences of the hospital environment.

In terms of changes in activity time, patients with fracture showed a larger effect size than did patients with stroke. Motor recovery mostly occurred within the first month after stroke, but some patients continued recovery up to 6 months after stroke[40]. This result may be associated with the different recovery period between stroke and fracture. On the other hand, both patients with stroke and those with fracture fell below the recommendations of the WHO[18] and no significant differences in characteristics were observed between patients with stroke and those with fracture regardless of changes in SB. The background underlying inactivity during hospitalization suggests that influences from the hospital environment (e.g., boredom, that eating and drinking are often performed while lying in bed, etc.) exert a negative influence on patients' physical activity levels[41]. Institutional priorities, staff culture, and attitudes may also exert negative influences on physical activity[42]. Therefore, during hospitalization, the environment may have more of an effect compared with that in the community, and differences between diagnoses may have less influence.

A key strength of the present study was that we objectively measured patients with stroke and those with fracture in the same setting. In the community setting, older adults with stroke are more inactive as measured by self-reported telephone surveys compared with older adults with other chronic diseases[15]. However, in the hospital setting, patients with stroke were as inactive as patients with fracture. This finding suggests that inactivity is more likely due to the hospital environment than to the effects of a specific diagnosis. Another strength of this study was that longitudinal comparisons were made by dividing activity time into therapy and non-therapy time. Most of the increases in activity time achieved during hospitalization were found to occur during non-therapy time.

The clinical application of this research should focus on non-therapy time to increase physical activity, regardless of the diagnosis leading to admission. In particular, this study provides evidence in support of the need for unsupervised interventions for patients capable of independent walking. In the future, it will be necessary to clarify which unsupervised interventions are most effective. The inactivity of patients during hospitalization is suggested to involve not only patient-related causes, but also the hospital environment-related causes[41]. However, further research is needed to clarify the types of hospital environments that influence inactivity.

This study has some limitations. First, a clear difference in the sex ratio was seen between patients with stroke and those with fracture. Among patients with stroke, some systematic reviews have found no significant association between sex and physical activity[7, 43]; only one known meta-analysis has concluded that a small association exists[44]. Therefore, comparisons of diagnoses that take sex differences into account are needed in the future. Second, during the follow-up phase, 17 patients with stroke and 10 with fracture dropped out of the study, which could have introduced a tapering bias. In this study, 59% of patients had missing data on physical activity at discharge because of the inability to wear the accelerometer for 3 days as a result of emergency discharge. Third, due to non-normal distribution of the data, we could not conduct analysis of variance. In addition, we could not detect whether there were moderate and small effects because the power was only sufficient to detect a large effect. Future studies with a larger sample should be conducted to clarify the relationships among multiple factors and effects. Fourth, the physical activity monitor with a triaxial accelerometer used in this study was tested for criterion validity in patients with stroke with a 6-minute walking speed of 2.2 ± 0.8 mph[31]. In a preliminary investigation, we confirmed that this physical activity monitor could identify LIPA in patients with a walking speed ≥ 0.15 m/s, but the accuracy for patients with a walking speed <0.15 m/s is not known. In the future, it will be necessary to confirm the validity of this device for patients with poor walking ability.

In conclusion, SB was decreased and LIPA and MVPA were increased at discharge compared with on admission. In particular, LIPA was increased in non-therapy time for both patients with stroke and those with fracture. Regarding increased activity, MVPA only occupied a few minutes. No differences in characteristics were observed between patients with stroke and those with fracture regardless of changes in SB. While physical activity levels increased during hospitalization, they remain below the WHO recommendations for MVPA, and patient characteristics alone may not account for this increased activity.

Conflict of interest

The authors have no conflicts of interest to disclose.

REFERENCES

1) Piercy KL, Troiano RP, Ballard RM, et al.: The Physical Activity Guidelines for Americans. JAMA, 2018, 320: 2020–2028. [Medline] [CrossRef]
2) Diep L, Kwagyan J, Kurantsin-Mills J, et al.: Association of physical activity level and stroke outcomes in men and women: a meta-analysis. J Womens Health (Larchmt), 2010, 19: 1815–1822. [Medline] [CrossRef]
3) Reinholdsson M, Palstam A, Sunnerhagen KS: Prestroke physical activity could influence acute stroke severity (part of PAPSIGOT). Neurology, 2018, 91: e1461–e1467. [Medline] [CrossRef]
4) Loprinzi PD, Addoh O: Accelerometer-determined physical activity and all-cause mortality in a National Prospective Cohort Study of adults post-acute stroke. Am J Health Promot, 2018, 32: 24–27. [Medline] [CrossRef]
5) Kono Y, Kawajiri H, Kamisaka K, et al.: Predictive impact of daily physical activity on new vascular events in patients with mild ischemic stroke. Int J Stroke, 2015, 10: 219–223. [Medline] [CrossRef]
6) Chapurlat RD, Bauer DC, Nevitt M, et al.: Incidence and risk factors for a second hip fracture in elderly women. The study of osteoporotic fractures. Osteoporos Int, 2003, 14: 130–136. [Medline] [CrossRef]
7) English C, Manns PJ, Tucak C, et al.: Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. Phys Ther, 2014, 94: 185–196. [Medline] [CrossRef]
8) Marques A, Peralta M, Martins J, et al.: Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults. Int J Public Health, 2017, 62: 495–502. [Medline] [CrossRef]
9) Baldwin C, van Kessel G, Phillips A, et al.: Accelerometry shows inpatients with acute medical or surgical conditions spend little time upright and are highly sedentary: systematic review. Phys Ther, 2017, 97: 1044–1065. [Medline] [CrossRef]
10) Simpson DB, Breslin M, Cumming T, et al.: Go home, sit less: the impact of home versus hospital rehabilitation environment on activity levels of stroke survivors. Arch Phys Med Rehabil, 2018, 99: 2216–2221.e1. [Medline] [CrossRef]
11) Bernhardt J, Borschmann K, Crock D, et al.: Stand up and be counted: measuring time spent upright after hip fracture and comparison with community dwelling older people. Physiotherapy, 2005, 91: 215–222. [CrossRef]
12) Marsault LV, Ryg J, Madsen CF, et al.: Objectively measured physical activity and its association with functional independence, quality of life and in-hospital course of recovery in elderly patients with proximal femur fractures: a prospective cohort study. Rehabil Res Pract, 2020, 2020: 5907652. [Medline]
13) Benzinger P, Lindemann U, Becker C, et al.: Geriatric rehabilitation after hip fracture. Role of body-fixed sensor measurements of physical activity. Z Gerontol Geriatr, 2014, 47: 236–242. [Medline] [CrossRef]
14) Barrett M, Snow JC, Kirkland MC, et al.: Excessive sedentary time during in-patient stroke rehabilitation. Top Stroke Rehabil, 2018, 25: 366–374. [Medline]
15) Ashe MC, Miller WC, Eng JJ, et al. Physical Activity and Chronic Conditions Research Team: Older adults, chronic disease and leisure-time physical activity. Gerontology, 2009, 55: 64–72. [Medline] [CrossRef]
16) Sylvia LG, Bernstein EE, Hubbard JL, et al.: Practical guide to measuring physical activity. J Acad Nutr Diet, 2014, 114: 199–208. [Medline] [CrossRef]
17) Strath SJ, Kaminsky LA, Ainsworth BE, et al. American Heart Association Physical Activity Committee of the Council on Lifestyle and Cardiometabolic Health and Cardiovascular, Exercise, Cardiac Rehabilitation and Prevention Committee of the Council on Clinical Cardiology, and Council: Guide to the assessment of physical activity: clinical and research applications: a scientific statement from the American Heart Association. Circulation, 2013, 128: 2259–2279. [Medline] [CrossRef]
18) Bull FC, Al-Ansari SS, Biddle S, et al.: World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med, 2020, 54: 1451–1462. [Medline] [CrossRef]
19) Baldwin CE, Phillips AC, Edney SM, et al.: Recommendations for older adults' physical activity and sedentary behaviour during hospitalisation for an acute medical illness: an international Delphi study. Int J Behav Nutr Phys Act, 2020, 17: 69. [Medline] [CrossRef]
20) Vandenbroucke JP, von Elm E, Altman DG, et al. STROBE Initiative: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. Epidemiology, 2007, 18: 805–835. [Medline] [CrossRef]
21) Viosca E, Martínez JL, Almagro PL, et al.: Proposal and validation of a new functional ambulation classification scale for clinical use. Arch Phys Med Rehabil, 2005, 86: 1234–1238. [Medline] [CrossRef]
22) Folstein MF, Folstein SE, McHugh PR: "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res, 1975, 12: 189–198. [Medline] [CrossRef]
23) Brunnstrom S: Motor testing procedures in hemiplegia: based on sequential recovery stages. Phys Ther, 1966, 46: 357–375. [Medline] [CrossRef]
24) Berg KO, Maki BE, Williams JI, et al.: Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil, 1992, 73: 1073–1080. [Medline]
25) Holden MK, Gill KM, Magliozzi MR, et al.: Clinical gait assessment in the neurologically impaired. Reliability and meaningfulness. Phys Ther, 1984, 64: 35–40. [Medline] [CrossRef]
26) Newell AM, VanSwearingen JM, Hile E, et al.: The modified Gait Efficacy Scale: establishing the psychometric properties in older adults. Phys Ther, 2012, 92: 318–328. [Medline] [CrossRef]
27) Dodds TA, Martin DP, Stolov WC, et al.: A validation of the functional independence measurement and its performance among rehabilitation inpatients. Arch Phys Med Rehabil, 1993, 74: 531–536. [Medline] [CrossRef]
28) Oshima Y, Kawaguchi K, Tanaka S, et al.: Classifying household and locomotive activities using a triaxial accelerometer. Gait Posture, 2010, 31: 370–374. [Medline] [CrossRef]
29) Ohkawara K, Oshima Y, Hikihara Y, et al.: Real-time estimation of daily physical activity intensity by a triaxial accelerometer and a gravity-removal classification algorithm. Br J Nutr, 2011, 105: 1681–1691. [Medline] [CrossRef]
30) Nagayoshi S, Oshima Y, Ando T, et al.: Validity of estimating physical activity intensity using a triaxial accelerometer in healthy adults and older adults. BMJ Open Sport Exerc Med, 2019, 5: e000592. [Medline] [CrossRef]
31) Shimizu N, Hashidate H, Ota T, et al.: The known-groups validity of intensity-based physical activity measurement using an accelerometer in people with

subacute stroke. J Phys Ther Sci, 2018, 30: 507–513. [Medline] [CrossRef]
32) Treacy D, Hassett L, Schurr K, et al.: Validity of different activity monitors to count steps in an inpatient rehabilitation setting. Phys Ther, 2017, 97: 581–588. [Medline] [CrossRef]
33) Sedentary Behaviour Research Network: Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours”. Appl Physiol Nutr Metab, 2012, 37: 540–542. [Medline] [CrossRef]
34) Ainsworth BE, Haskell WL, Herrmann SD, et al.: 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc, 2011, 43: 1575–1581. [Medline] [CrossRef]
35) Askim T, Bernhardt J, Churilov L, et al.: Changes in physical activity and related functional and disability levels in the first six months after stroke: a longitudinal follow-up study. J Rehabil Med, 2013, 45: 423–428. [Medline] [CrossRef]
36) Skarin M, Sjöholm A, Nilsson Å, et al.: A mapping study on physical activity in stroke rehabilitation: establishing the baseline. J Rehabil Med, 2013, 45: 997–1003. [Medline] [CrossRef]
37) Kubo H, Kanai M, Nozoe M, et al.: Daily steps are associated with walking ability in hospitalized patients with sub-acute stroke. Sci Rep, 2022, 12: 12217. [Medline] [CrossRef]
38) Shimizu N, Hashidate H, Ota T, et al.: Characteristics of intensity-based physical activity according to gait ability in people hospitalized with subacute stroke: a cross-sectional study. Phys Ther Res, 2019, 22: 17–25. [Medline] [CrossRef]
39) Theou O, Kehler DS, Godin J, et al.: Upright time during hospitalization for older inpatients: a prospective cohort study. Exp Gerontol, 2019, 126: 110681. [Medline] [CrossRef]
40) Bonita R, Beaglehole R: Recovery of motor function after stroke. Stroke, 1988, 19: 1497–1500. [Medline] [CrossRef]
41) Koenders N, Marcellis L, Nijhuis-van der Sanden MW, et al.: Multifaceted interventions are required to improve physical activity behaviour in hospital care: a meta-ethnographic synthesis of qualitative research. J Physiother, 2021, 67: 115–123. [Medline] [CrossRef]
42) Janssen H, Bird ML, Luker J, et al.: Impairments, and physical design and culture of a rehabilitation unit influence stroke survivor activity: qualitative analysis of rehabilitation staff perceptions. Disabil Rehabil, 2022, 44: 8436–8441. [Medline] [CrossRef]
43) Field MJ, Gebruers N, Shanmuga Sundaram T, et al.: Physical activity after stroke: a systematic review and meta-analysis. ISRN Stroke, Hindawi, 2013, 2013.
44) Notthoff N, Reisch P, Gerstorf D: Individual characteristics and physical activity in older adults: a systematic review. Gerontology, 2017, 63: 443–459. [Medline] [CrossRef]