Original Article

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Physical Activity and Activities of Daily Living in Older Adult Patients With Heart Failure Admitted for Subacute Musculoskeletal Disease

Tomoko Shimizu, RPT, MSc[1,2], Chiaki Kanai, OTR, MSc[1,2], Keisuke Ueda, MD, PhD[1], Yasuyoshi Asakawa, PhD[2]

[1]*Department of Rehabilitation, The Anti-Tuberculosis Association, Shin-Yamanote Hospital, Tokyo, Japan*
[2]*Department of Physical Therapy, Graduate School of Human Health Science, Tokyo Metropolitan University, Tokyo, Japan*

Objective: To examine activities of daily living (ADL) and physical activity in older adults with heart failure admitted to a rehabilitation ward for subacute musculoskeletal disease.
Methods: This study included patients with musculoskeletal disease (aged ≥75 years) who were admitted to the rehabilitation ward. Data on age, ADL, and time for physical activity (metabolic equivalents [METs]) were collected. Patients were divided into groups with or without heart failure, and the differences were compared using Mann–Whitney U-test.
Results: This study included 84 musculoskeletal patients, including 25 with heart failure. The heart-failure group had similar levels of ADL independence compared to the without-heart-failure group ($p=0.28$) but had shorter duration of continuous and sustained physical activities and less total time ($p<0.01$) of light-intensity physical activity or higher.
Conclusion: Older adults with subacute musculoskeletal disease with heart failure do not necessarily require a large amount of physical activity to maintain ADL at the time of discharge. But very low physical activity may increase the risk for developing hospitalization-associated disability. Physical activity in older adults with subacute musculoskeletal disease with heart failure should be monitored separately from ADL.

Keywords: Activities of daily living, Heart failure, Aged, Sedentary behavior, Musculoskeletal disease

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Correspondence:
Tomoko Shimizu
Department of Rehabilitation, The Anti-Tuberculosis Association, Shin-Yamanote Hospital, 3-6-1, Suwa-cho, Higashimurayama-shi, Tokyo 189-0021, Japan.
Tel: +81-42-391-1425
Fax: +81-42-391-5760
E-mail: tshimizu.tmu@gmail.com

INTRODUCTION

Japan has one of the fastest aging populations worldwide. The number of heart failure patients in Japan, especially among older adults, is rapidly increasing [1]. The main clinical features of heart failure include physical inactivity with fatigue, shortness of breath, and mental distress [2]. In older adults, heart failure leads to a decreased tolerance for exercise, and eventually to an impairment in the ability to perform activities of daily living (ADL) [3,4]. A meta-analysis of the prevalence of ADL impairment in heart failure patients revealed that Japan had the highest prevalence at 58.2% [5]. In older inpatients, medical triggering events or complications, such as a decline in mobility and function due to bed rest [6] and hospitalization-associated disability, may occur due to less light-intensity physical activity [7]. Older inpatients may be treated in a convalescent rehabilitation ward to prevent physical decline, avoid prolonged bed rest, improve the performance of ADL, and establish independent living [8].

According to the Ministry of Health, Labor and Welfare [9], in people aged 75 years and older, symptoms due to decline in physiological function and the ability to perform ADL increase, and comprehensive management of symptoms of multiple chronic diseases is important. The prevalence of multiple chronic diseases is expected to increase in patients with heart failure, in particular in patients with musculoskeletal disease, where incidence increases with age [10]. Patients with chronic heart disease have altered function of the myosin molecule in skeletal muscle, resulting in muscle weakness, reduced physical activity level and ability to maintain balance [11], and increased risk for falls [12]. Gerber et al. [13] reported that in chronic heart failure patients older than 80 years, the incidence of femur fracture is 2.3-times higher in male and 4.18-times higher in female than that in patients without heart failure. Rahman et al. [14] reported that in older adults with chronic heart failure, osteoarthritis was 25% higher in male and 20% higher in female than that in those without heart failure.

For inpatients with musculoskeletal disease with femur fractures and knee osteoarthritis, rehabilitation through an interdisciplinary care program, focusing on physical exercise, is generally provided to improve motor function and ADL compromised by orthopedic injury to the best extent [15,16], which is required to assess the patient's independence in ADL and physical activities during hospitalization. It is predictable that physical activity may inevitably be limited in patients with heart failure. It is not well known whether the independence in ADL is actually low and how much physical activity is low among older adult musculoskeletal disease patients with heart failure admitted to a convalescent rehabilitation ward.

The purpose of this study was to investigate independence in ADL and physical activities with heart failure patients aged 75 years and older who were admitted to a convalescent rehabilitation ward due to subacute musculoskeletal disease, and to compare them with or without heart failure patients.

METHODS

Setting

This cross-sectional study was conducted between February 2020 and April 2021 in a 16-bed recovery rehabilitation ward attached to a secondary emergency hospital in Tokyo, Japan, which consisted of seven inpatient departments, 18 outpatient departments, and five 180-bed wards.

The applicable diseases, services, and duration of stay for convalescent rehabilitation wards are based on the medical fee determined by the government. The convalescent rehabilitation fee in the medical fee system ranges from 1 to 6, depending on the facility's standards. Differences in facility standards include the number of staff, availability of rehabilitation services on holidays, percentage of severe disease patients, and achievement quotas. Hospitalization fee-1 has the highest allocation of human resources and the highest achievement quota. The facility standard in this study was Hospitalization fee-5.

The facilities also provide treatment by specialists in each department for each of the complex diseases during hospitalization in the convalescent rehabilitation wards. For example, respiratory disease is treated by respiratory specialists, cardiovascular diseases by cardiology specialists, and gastrointestinal diseases by gastroenterology specialists, while liver, renal, allergic, and metabolic diseases including diabetes are treated by general internal medicine specialists, and mental disorders by psychosomatic medicine and clinical psychologists, forming a team for each patient. Pain is treated immediately after admission and continuously with oral and transdermal analgesics depending on the pain level and chronic disease status by an orthopedic surgeon and/or internist. Patients with severe conditions requiring treatment, such as patients with respiratory, hepatic, or renal disorders and patients with New York Heart Association (NYHA) functional classification class-III or higher [17] are treated in the acute care unit, not transferred to the convalescent rehabilitation ward. The heart failure patients included in this study were those who were diagnosed with heart failure in other departments and transferred to the convalescent rehabilitation unit, and due to the conditions of the convalescent rehabilitation hospital, NYHA class-II patients were of the majority. Patients were assessed by the attending physician and those with stable heart failure symptoms and able to tolerate practicing ADL were allowed to be transferred to the convalescent rehabilitation ward for the primary purpose of practicing ADL, even if their subjective symptoms were categorized as NYHA class-III. Patients received personalized one-on-one rehabilitation with a therapist for 1–2 hours per day during the rehabilitation hours. Personalized rehabilitation includes basic action practice, strength training, ADL, gait practice, and endurance exercise. In the presence of many comorbidities, the guidelines followed the general principle of exercise prescription, which states that "a combined exercise regimen consisting of aerobic exercise, resistance training, balance training, and flexibility exercises should be considered to improve exercise capacity and physical function [18]," under the judgment and direction of the attending physician.

This facility surveyed physical activity in patients aged 75 years and older who were hospitalized for musculoskeletal diseases and examined the data on physical activity at discharge.

Participants

The participants were subacute musculoskeletal patients admitted to the recovery rehabilitation ward. Subacute phase in this study is defined as the period from the day of transfer to the rehabilitation ward to the day of discharge. The patient's transfer was permitted by the attending physician based on a combination of factors, including removal of the indwelling bladder catheter, no signs of wound infection, and the ability to take the required amount of food orally. Musculoskeletal disease is defined as the applicable conditions for admission to the convalescent rehabilitation ward, as follows: fractures of the femur, pelvis, vertebra, hip joints, knee joint, and hip joint replacement or knee joint replacement. The inclusion criteria for participants were as follows: (1) ≥75 years of age; (2) those who provided consent to participate in the study; and (3) a musculoskeletal disease applicable for admission to the convalescent rehabilitation ward. The exclusion criteria were as follows: (1) an admission diagnosis of a condition other than musculoskeletal disease; (2) comorbid disorders, long-term fever symptoms, and limitations in therapeutic or medical activities due to lower limb load restriction; (3) a mental state that would impair decision-making regarding participation in the study, including delirium; and (4) unstable mental or physical conditions and a high possibility of a sudden change in short-term physical conditions, judged by the physician upon admission into the ward.

Sample size

The required sample size was set at 80 participants using G*power (https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower) as follows: Wilcoxon–Mann–Whitney test (two groups), two tails, effect size 0.5, α err prob 0.05, power (1-β err prob) 0.5, and an allocation ratio of 2/1.

Ethics

This study was approved by the Institutional Review Board of The Anti-Tuberculosis Association, Shin-Yamanote Hospital (No. 19001) and by the research ethics committee of the Tokyo Metropolitan University, Arakawa Campus (No. 20038). Participants were informed of the content and purpose of the study verbally and in writing, and they provided written informed consent.

Data collection

Participant characteristics data

Potential confounders included age, sex, body mass index (BMI), length of hospital stay, ability to perform ADL, type of musculoskeletal disease diagnosed on admission, medical history, and mobility. Predictors included the presence of a history of heart failure. Outcomes were bout duration and the total time of physical activity classified by activity intensity. For patients with heart failure, the data on cardiac function variables were collected as patient characteristics.

Age, sex, BMI, length of hospital stay, the ability to perform ADL, musculoskeletal disease diagnoses, cardiac function variables, medical history, and mobility at discharge were collected from patient medical records. BMI was calculated by dividing the weight (kg) by height^2 (m^2). To assess the ability to perform ADL, the Functional Independent Measure (FIM) was selected as the evaluation index. FIM compares movement ability objectively independent of the patient's use of assistive devices, such as wheelchairs, walkers, canes, and railings, or communication skills, such as hearing, vision, verbal comprehension, and non-verbal comprehension. FIM quantifies the amount of ADL assistance provided to the patient and consists of 13 motor and five cognitive items on a 7-point scale ranging from 7 to 1 each, for a total score of 126 to 18 [19,20]. The data on FIM scores were collected from the medical records of entry and discharge conferences and were assessed by the ward nurses. "FIM at entry" was assessed within 24 hours of entry to the ward, and "FIM at discharge" was assessed the day before discharge. Preadmission indoor mobility was examined after admission based on the Living Space Assessment (LSA) [21]. The patients' level of independence according to the LSA level-3 categories "been to a neighborhood other than their yard or apartment during the past four weeks," and "needs help from others" were classified in our study as "personal assistance," while "equipment only," and "no equipment or personal assistance" were classified as "unassisted." For indoor mobility at the time of discharge, locomotion was assessed under the FIM motor domain and "walking" or "wheelchair" scores were collected for assessment. Walking with a cane or walker was classified as "walking," and those who were unable to walk 50 m (FIM walking score≤4) were classified as "wheelchair users" regardless of whether they were independent wheelchair users. The musculoskeletal diseases that caused hospitalization were identified and recorded upon admission to the convalescent rehabilitation wards. A medical history of diabetes was included as patient characteristic variable because its incidence correlates inversely with the amount of physical activity [22]. The diagnosis of diabetes mellitus was based on hemoglobin A1c levels, ongoing treatment, and diagnostic history in the medical record. History of cerebrovascular disease was included as a patient characteristic variable because its sequelae are considered to increase the risk for reduced physical activity and ADL impairment [23]. The diagnosis of cerebrovascular disease was based on the medical history of previous stroke and cerebral hemorrhage, regardless of the severity of sequelae or the regular prescriptions. All study participants with a history of cerebrovascular disease were in the living phase of the disease, more than 6 months after disease onset.

Heart failure in this study was defined as having a diagnosis of heart failure, being on cardiovascular medication, and subjective symptoms with NYHA functional class-II or higher [17] prior to the onset of musculoskeletal disease: NYHA class-I, no symptoms with normal physical activity and function status; NYHA class-II, mild symptoms with normal physical activity, comfortable at rest, slight limitation of functional status, clinically walking more than two blocks on the level and climbing more than one flight of ordinary stairs, and performing to completion of any activity requiring 5 metabolic equivalents (METs); NYHA class-III, moderate symptoms with less than normal physical activity, comfortable only at rest, marked limitation of functional status, clinically walking one to two blocks on the level and climbing one flight of stairs, and patient can perform to completion of any activity requiring >2 METs; and NYHA class-IV, severe symptoms with features of heart failure with minimal physical activity and even at rest, severe limitation of functional status [17,24]. The research facility is a specialized rehabilitation ward for musculoskeletal diseases, and as a rule, does not accept patients in NYHA class-III or higher.

Division into groups with or without heart failure

Participants with the diagnosis of heart failure among patients with musculoskeletal disease were assigned to “with heart failure” group. Participants who were never diagnosed with heart failure, regardless of how many diseases they had, were assigned to the “without heart failure” group. Cardiac function indices of participants with heart failure were collected for presenting participant characteristics, as follows: brain natriuretic peptide (BNP) (pg/mL) which reflect worsening or improving hemodynamics, left ventricular ejection fraction (LVEF) (%), E velocity divided by A-wave velocity (E/A ratio), average E velocity divided by mitral annular e’ velocity (average E/e’), septal e’ velocity (cm/s), and tricuspid regurgitation (TR) velocity (m/s) as an echocardiographic parameter when investigating the cause of heart failure [25]. BNP test and echocardiography are not part of the usual practice for musculoskeletal disease. They are performed only when risk screening for cardiac function is appropriate at the start of musculoskeletal disease treatment. Subsequent echocardiographic testing was not performed. The conditions of participants with heart failure are assessed by BNP levels and clinical findings as needed.

Measurements

Accelerometer-measured physical activity

Physical activity was measured by attaching a triaxial accelerometer (Active Style Pro HJA750c; OMRON HEALTHCARE Co., Ltd) to the participant’s waist. For the device, the validity and reliability of the measurements compared to expiratory gas analysis and doubly labeled water method has been shown for physical activity under free-living, including walking and non-ambulatory activities (such as reading, office work, and cleaning) [26-28]. Based on physical activity measurement methods in patients with heart failure from previous studies, the period of wear was initiated at least 4 days prior to discharge and comprised 24 consecutive hours, excluding bathing, for at least 3 days [29]. Data were analyzed for 15 hours during the day, from the wake-up time at 6:00 to the lights-out time at 21:00, based on the schedule of the facility. If the acceleration signal was zero for more than 120 minutes in a 15-hour period, it was considered as non-attached [30], and the corresponding day was excluded from the analysis as missing data. The data of patients with valid 3-day records were analyzed.

Physical activity intensity was expressed in METs. Activity intensity was classified according to sedentary behavior (1.0–1.5 METs), light-intensity physical activity (1.6–2.9 METs), and moderate-to-vigorous intensity physical activity and higher (≥3.0 METs) [31]. Activity intensity was calculated for light-intensity physical activity or higher (≥1.6 METs) and moderate-to-vigorous-intensity physical activity or higher (≥3.0 METs). For example, 1.5 METs: sitting, knitting, sewing; 2.0 METs: walking at less than 2.0 mph on level ground; 2.5 METs: light cleaning (dusting, straightening up, changing linen, and carrying out trash); 3.0 METs: walking at 2.5 mph; 3.5 METs:

standing, packing boxes, occasional lifting of household materials; and 3.8 METs: walking at 3.5 mph [31].

The data processing procedure for physical activity was as follows: (1) Activity intensity was compiled into time series on a Microsoft excel sheet at 10-s intervals by the data reading application of the used device. (2) Total activity time was calculated by counting the number of cells for each activity intensity. (3-1) "Single continuous period" was defined as the time when bout cells of the same activity intensity continued, and the value and frequency of occurrence of each were calculated. (3-2) "Single continuous period per hour" was used in the analysis for the longest value that occurred at least 45 times during the 45 hours of measurement in 3 days. For example, during the 45-hours, if 90-second single continuous period occur 5 times and 100-second single continuous period occur 40 times, since the 90-second single continuous period is included in the 100-second single continuous period, we use the value of 90-second single continuous period in the analysis.

Patients who required care in wearing and removing the device when changing clothes were assisted by ward and rehabilitation department staff, to prevent data loss due to forgetting to wear the device.

Statistical analysis

Participant characteristics data

The distribution of data for age, BMI, length of stay, and FIM scores were examined for normality using Shapiro–Wilk test, and descriptive statistics were performed. The analysis using non-parametric tests is as follows. To compare differences in BNP data between entry and discharge, Wilcoxon signed-rank test was used. To compare differences between with heart failure and without heart failure groups, Mann–Whitney U-test was used for continuous scale data, and χ^2 test or Fisher's exact test was used for sex, medical history, and mobility. As an analysis using parametric tests, the difference in change in FIM with and without heart failure was examined using two-way ANOVA.

Physical activity

The physical activity data distribution was checked using the Shapiro–Wilk test, and descriptive statistics were performed. To compare differences between with heart failure and without heart failure groups, the Mann–Whitney U-test was used with non-parametric tests. Effect size indices were examined for the non-parametric test, r ($=Z/\sqrt{N}$, Z: test statistic), and for the chi-squared test, φ. For additional analysis with parametric tests, multiple regression analysis forced entry method was used to extract risk factors, with physical activity as the dependent variable and patient characteristics variable as the independent variable. Next, repeated measures analysis of covariance (ANCOVA) was performed with the patient characteristics variable extracted as a risk factor as the covariate and the independent variable as the presence of heart failure.

Statistical analysis were performed using IBM SPSS Statistics 26 (IBM Corp.) and the significance probability was 5%.

RESULTS

Participant characteristics

A total of 84 participants were included in the study, including 25 with heart failure. No one failed to finish the study due to exacerbation of heart failure during the study period. The number of participants in each phase of the study is shown in the flowchart in Fig. 1. The descriptive statistics for all participants were as follows: age, 85 years (80.8–89.0 years) (median [interquartile range, 25th percentile–75th percentile]); female patients, 63 (75.0%), BMI, 20.5 (18.3–24.0) kg/m^2; duration of stay in the recovery rehabilitation ward, 30.5 (20.0–50.3) days; FIM at entry, 85.5 (72.0–96.0) points; FIM at discharge, 108.0 (96.5–117.0) points; number of patients with postoperative femur fracture, 38 (45.2%); number of patients under treatment for diabetes mellitus, 27 (32.1%); number of patients with a history of cerebrovascular disease, 12 (14.3%); number of patients with independent indoor mobility prior to admission due to musculoskeletal disease, 74 (88.1%); and number of patients discharged ambulatory, 78 (91.7%; Table 1).

No differences were found for all variables of participant characteristics between the with heart failure and without heart failure groups: age, sex, BMI, days from onset of musculoskeletal disease to ward transfer, length of ward stay, FIM at entry, type of orthopedic disease, diabetes mellitus, cerebrovascular disease, and mobility at preadmission and discharge (p=0.44, p=0.28, p=0.47, p=0.16, p=0.29, p=0.08, p=0.10, p=0.32, p=0.77, p=0.14, and p=0.11, respectively; Table 1). Similarly, no difference was found in FIM at discharge between the with heart failure group (108.0 [86.0–113.0] points) and without heart failure group (109.0 [97.5–117.0] points; p=0.28; Table 1). There was no statistical significance in the results of multivariate analysis of the difference in FIM score change between entry and discharge with and without heart failure (two-way ANOVA, p=0.40; Table 1). Risk factors affecting physical ac-

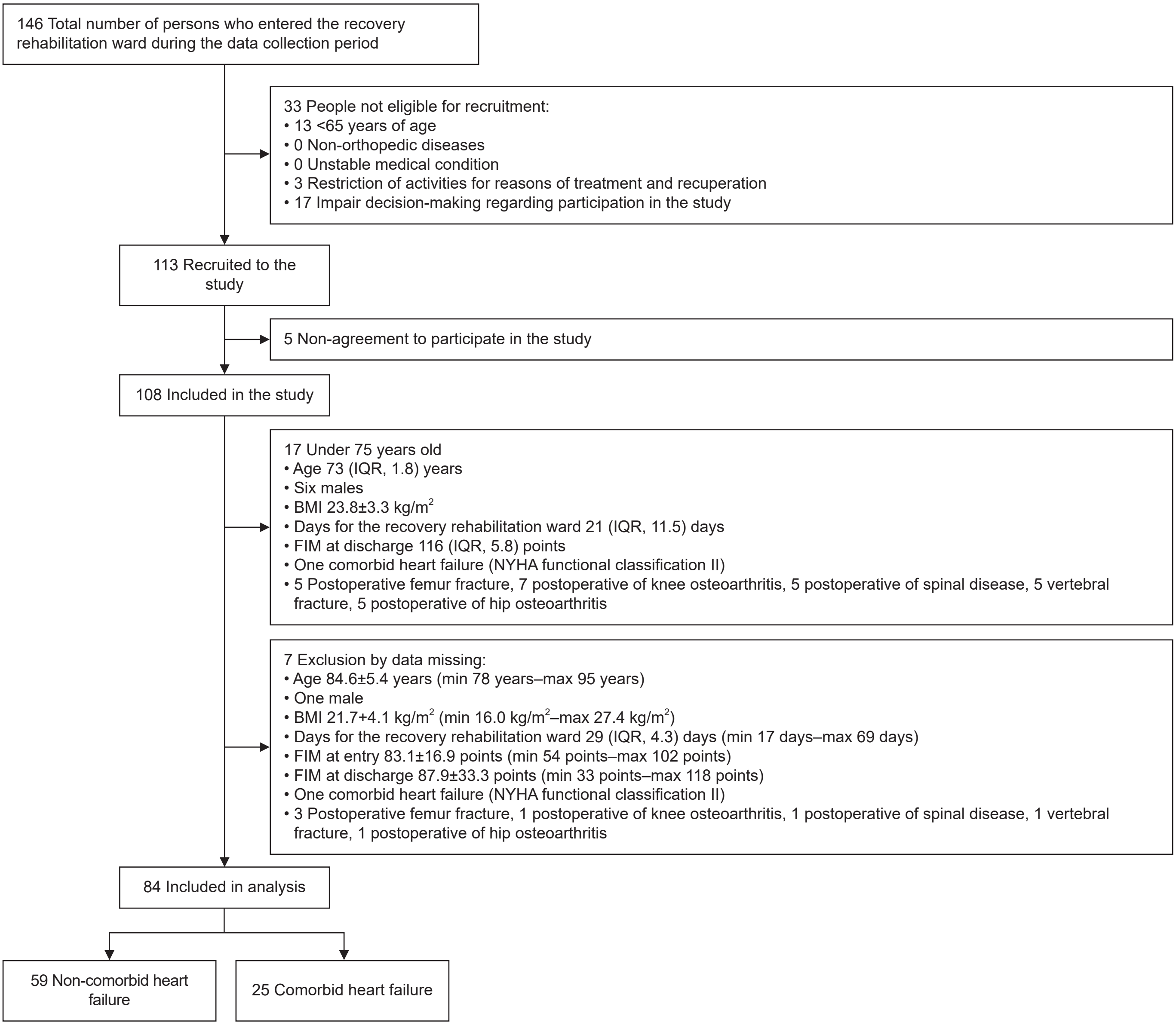

Fig. 1. This image presents a flowchart of study participant selection. IQR, interquartile range; BMI, body mass index; FIM, Functional Independent Measure; NYHA, New York Heart Association; min, minimum; max, maximum.

tivities were age and FIM at discharge (Table 2). Clinical data on cardiac functions for participants with heart failure BNP decreased from 124.5 (72.6–221.8) pg/mL at admission to 76.4 (42.7–182.5) pg/mL at discharge, but not significantly (p=0.11). LVEF was 67.0% (60.0%–72.0%; Table 3). Fourteen of the 25 patients had diastolic dysfunction and three had systolic and diastolic dysfunction. Other patients with heart failure had atrial fibrillation and tachyarrhythmia and were on drug therapy. Patients underwent outpatient treatment at home and had stable cardiac function. The study defined heart failure by NYHA classification based on subjective symptoms and drug therapy, the NYHA classification II and III and comprised 20 (80.0%) and 5 (20.0%) patients, respectively. Five participants of NYHA class-III were diagnosed with occasional complaints of palpitations and fatigue, but usually had only mild subjective symptoms.

Physical activities

Descriptive statistics for all physical activities were 180 (130–

Table 1. Characteristics of participants

	All (n=84)			With heart failure (n=25)			Without heart failure (n=59)			p-value[a),b),c)]	Effect size[a),b),c)]
	Value	Min	Max	Value	Min	Max	Value	Min	Max		
Age (yr)	85.0 (80.8–89.0)	76	98	86.0 (80.0–91.0)	76.0	95.0	85.0 (81.0–87.5)	76	98	0.44[a)]	0.08[d)]
Body mass index (kg/m^2)	20.5 (18.3–24.0)	14.2	30.5	20.2 (17.8–22.7)	15.0	30.5	21.6 (19.0–24.4)	14.2	30.1	0.47[a)]	0.08[d)]
Days from onset to admission to the rehabilitation ward (day)	13.0 (9.8–17.0)	0	70	15.0 (9.0–26.0)	7	48	13.0 (10.0–15.0)	0	70	0.16[a)]	0.23[d)]
Days for the rehabilitation ward (day)	30.5 (20.0–50.3)	10	88	34.0 (23.0–64.0)	10	88	29.0 (20.0–44.5)	12	79	0.29[a)]	0.11[d)]
FIM (point)											
At entry	85.5 (72.0–96.0)	33	119	76.0 (60.0–96.0)	33	111	86.0 (76.0–96.0)	51	119	0.08[a)]	0.15[d),f)]
At discharge	108.0 (96.5–117.0)	41	124	108.0 (86.0–113.0)	41	122	109.0 (97.5–117.0)	78	124	0.28[a)]	0.19[d),f)]
Sex										0.28[b)]	0.14[e)]
Male	21 (25.0)			4 (16.0)			17 (28.8)				
Female	63 (75.0)			21 (84.0)			42 (71.2)				
Postoperative femur fracture										0.10[b)]	0.19[e)]
Postoperative femur fracture	38 (45.2)			15 (60.0)			23 (39.0)				
Other than postoperative femur fracture	46 (54.8)			10 (40.0)			36 (61.0)				
Postoperative knee joint replacement	22			2			20				
Conservative treatment for osteoporotic compression fracture	9			3			6				
Postoperative osteoporotic compression fracture	7			2			5				
Postoperative spinal canal stenosis	5			3			2				
Postoperative hip joint replacement	3			0			3				
Diabetes mellitus	27 (32.1)			10 (40.0)			17 (28.8)			0.32[b)]	0.11[e)]
History of cerebrovascular disease	12 (14.3)			4 (16.0)			8 (13.6)			0.77[c)]	0.04[e)]
Preadmission indoor mobility—unassisted	74 (88.1)			20 (80.0)			54 (91.5)			0.14[b)]	0.16[e)]
Indoor mobility at discharge—ambulation	78 (92.9)			21 (84.0)			56 (94.9)			0.11[c)]	0.18[e)]

Values are presented as median (interquartile range [25th percentile–75th percentile]), number (%), or number only.
Min, minimum; Max, maximum; FIM, Functional Independent Measure.
[a)]Mann–Whitney U-test, [b)]chi-squared test, [c)]Fisher's exact test, [d)]$r=Z/\sqrt{N}$, and, [e)]φ. [f)]Analysis of the difference in FIM score change between entry and discharge with and without heart failure by two-way ANOVA, p=0.40.

220) seconds for a single continuous period of light-intensity physical activity or higher, 15 (10–20) seconds of moderate-to-vigorous-intensity physical activity or higher, 14,913.4 (10,569.2–19,502.5) seconds total time of light-intensity physical activity or higher, and 633.4 (354.6–927.5) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4). Descriptive statistics for physical activity in the group with heart failure were 130 (120–200) seconds for a single continuous period of light-intensity physical activity or higher, 10 (10–20) seconds for moderate-to-vigorous-intensity physical activity or higher, 11,296.6 (8,603.3–16,186.7) seconds total time of light-intensity physical activity or higher, and 383.3 (296.7–613.3) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4). Descriptive statistics for physical activity in the without heart failure group were 190 (150–220) seconds for a single continuous period of light-intensity physical activity or higher, 20 (10–20) seconds of moderate-to-vigorous-intensity physical activity or higher,

Table 2. Analysis of risk factors for physical activities

Factor	Physical activities							
	Single continuous period				Total time			
	≥LIPA		MVPA		≥LIPA		MVPA	
	Adjusted R^2: 0.31		Adjusted R^2: -0.03		Adjusted R^2: 0.32		Adjusted R^2: 0.10	
	p-value	Standardized coefficients	p-value	Standardized coefficients	p-value	standardized coefficients	p-value	Standardized coefficients
Intercept	0.038*		0.77		0.25		0.55	
Sex	0.17	0.1	0.31	0.12	0.029*	0.20	0.14	0.16
Age	0.007*	-0.3	0.65	0.06	0.031*	-0.23	0.87	0.02
FIM at discharge	0.002*	0.3	0.12	0.21	<0.001*	0.40	0.010	0.33
Days for recovery ward	0.44	0.1	0.63	0.06	0.30	0.10	0.80	-0.03
Chronic heart failure	0.007*	-0.3	0.35	-0.11	0.020*	-0.23	0.07	-0.20
Postoperative femur fractures	0.014*	0.1	0.50	-0.01	0.12	0.06	0.67	-0.02
Diabetes mellitus	0.28	0.0	0.97	0.08	0.52	-0.08	0.88	-0.07
Cerebrovascular disease	0.85	0.3	0.51	0.08	0.38	0.16	0.55	0.05

Multiple liner regression forced-entry method was used for analysis; outcomes were physical activities; factors were sex, age, FIM at discharge, days for recovery ward, chronic heart failure, postoperative femur fractures, diabetes mellitus, and cerebrovascular disease.
LIPA, light-intensity physical activity; MVPA, moderate to vigorous physical activity; FIM, Functional Independent Measure.
*p<0.05.

Table 3. Clinical data on cardiac function in patients with heart failure

	Value	Minimum	Maximum	p-value[a]	Effect size[b]
NYHA functional classification					
I	0 (0)				
II	20 (80.0)				
III	5 (20.0)				
IV	0 (0)				
Parameters of cardiac function					
BNP (pg/mL)				0.11	0.27
At admission	124.5 (72.6–221.8)	10.0	800.0		
At discharge	76.4 (42.7–182.5)	11.6	555.0		
LVEF (%)	67.0 (60.0–72.0)	36.0	81.0		
Average E/e’	13.6 (10.4–16.6)	7.1	28.4		
E/A	0.7 (0.6–0.9)	0.5	3.4		
Septal e’ velocity (cm/s)	5.0 (4.5–7.0)	3.0	8.0		
TR velocity (m/s)	2.3 (1.9–2.5)	1.6	3.4		

Values are presented as number (%) or median (interquartile range [25th percentile–75th percentile]).
NYHA, New York Heart Association; BNP, brain natriuretic peptide; LVEF, left ventricular ejection fraction; Average E/e', average E velocity divided by average mitral annular e' velocity; E/A, E velocity divided by A-wave velocity; TR, tricuspid regurgitation.
[a]Wilcoxon signed-rank test and [b]$r=Z/\sqrt{N}$.

15,273.3 (12,270.0–20,546.7) seconds total time of light-intensity physical activity or higher, and 730 (538.4–1,071.7) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4).

Between the with heart failure and without heart failure groups, differences were found in single continuous period of light-intensity physical activity or higher (p=0.004), moderate-to-vigorous-intensity physical activity or higher (p=0.019), total activity time of light-intensity physical activity or higher (p=0.005), and moderate-to-vigorous intensity physical activity or higher (p<0.001). The heart failure group had a shorter duration of physical activity for all variables in univariate analysis (Table 4). Age and FIM were selected as risk factors of physical activity according to the results of multiple regression analysis (Table 3). The single continuous period for light-intensity physical activity or higher was shorter in the heart failure group in the multivariate analysis with age and FIM as covariates (Table 4).

Table 4. Physical activities

	All (n=84)			With heart failure (n=25)			Without heart failure (n=59)			p-value[a)]	Effect size	p-value of ANCOVA[b)]
	Median (IQR)	Min	Max	Median (IQR)	Min	Max	Median (IQR)	Min	Max			
Single continuous period (s)												
≥Light-intensity physical activity	180.0 (130.0–220.0)	110.0	300.0	130.0 (120.0–200.0)	70	300	190.0 (150.0–220.0)	110	310	0.004*	0.32	0.013*
Moderate to vigorous physical activity	15.0 (10.0–20.0)	10.0	20.0	10.0 (10.0–20.0)	10	50	20.0 (10.0–20.0)	10	21	0.019*	0.26	0.44
Total time (s)												
≥Light-intensity physical activity	14,913.4 (10,569.2–19,502.5)	7,428.0	25,950.9	11,296.6 (8,603.3–16,186.7)	4,485.0	26,086.6	15,273.3 (12,270.0–20,546.7)	7,050.0	33,433.4	0.005*	0.32	0.032*
Moderate to vigorous physical activity	633.4 (354.6–927.5)	201.2	1,560.5	383.3 (296.7–613.3)	150.0	2613.3	730.0 (538.4–1,071.7)	143.3	1,873.3	<0.001*	0.39	0.05

IQR, interquartile range (25th percentile–75th percentile); Min, minimum; Max, maximum; ANCOVA, analysis of covariance.
[a)]Mann-Whitney U-test, [b)]covariate: age, Functional Independent Measure at discharge.
*p<0.05.

DISCUSSION

The purpose of this study was to investigate independence in ADL and physical activities with heart failure patients aged 75 years and older who were admitted to a convalescent rehabilitation ward due to subacute musculoskeletal disease and to compare them with or without heart failure patients. The heart failure patients included in this study were those who were diagnosed with heart failure in other departments and transferred to the convalescent rehabilitation unit, and due to the conditions of the convalescent rehabilitation hospital, NYHA class-II patients were of the majority. This study showed that patients with heart failure had no significant differences in ADL but did have differences in physical activity compared to patients without heart failure.

The characteristics of cardiac function in the heart failure group in this study were three as follows: most were of NYHA class-II with minimal subjective impairment in ADL; left ventricular ejection rate was preserved as indicated by the LVEF values; their heart overload was slightly high according to the BNP values, although the cause of admission was musculoskeletal disease. BNP values did not change statistically significantly during hospitalization, indicating that cardiac overload remained unchanged. In this study, there was no difference in the level of independence in ADL at entry and discharge between musculoskeletal disease patients with heart failure and those without heart failure. Limitations of ADL were considered likely to have been determined by musculoskeletal disease rather than heart failure. In older adult patients, the number and combination of multiple morbidities and the difficulties they face in their daily lives differ with each person. It is assumed that in the convalescent rehabilitation ward, support and facilitation to maximize the patient's ADL functions are performed depending on the patient's individuality. The ADL at the time of discharge were considered to be the result of demonstrating actual ADL as a patient of subacute musculoskeletal disease.

The single continuous period of physical activity in this study was 180 seconds for light-intensity physical activity or higher. The reported average walking time of hospitalized older adults was <2 minutes per observation period [32]. Light-intensity physical activity or higher includes walking, slow walking, and ADL and basic actions that occur back and forth associated with walking [33]. Therefore, the operation durations measured in this study were considered reasonable. For the total time of physical activity, participants in the study were 75 years and older, with an average age of 85 years. A systematic review of physical activity in hospitalized adults of 25–85 years of age with musculoskeletal disease reported that inpatients spent 76%–99% of their time supine or inactive [34]. The activity time, 1%–24%, was calculated to be 0.24–5.76 hours per 24 hours. Considering that the participants in this study were aged 75 years and older and not fully independent in ADL, the total activity time indicated in this study of 14,913 seconds (4.1 hours) was considered reasonable. It has been reported that the walking time of hospitalized older adults with geriatric disease is 10 minutes at discharge [35]. The results of this study showed that a total duration of 633 seconds (10.6 minutes) of moderate-to-vigorous physical activity was equivalent to “walking,” which supported the findings of the previous study.

There were no differences between the participant characteristics variables for patients with and without heart failure. Therefore, it was considered that heart failure affected the difference in shorter physical activity. In general, for patients with subacute musculoskeletal disease, the more physical activity they have, the better their ADL. However, the results showed that participants with heart failure did not necessarily require greater amounts of physical activity to maintain ADL. There may be appropriate values for the physical activity duration for each patient with heart failure, regardless of the independence level of ADL. Regarding the difference in the duration of physical activity with and without heart failure, we consider that some kind of hypometabolism or muscle degeneration might be related to the amount of physical activity. Dysfunction of brawn adipose tissue (BAT) has been shown to occur with heart failure [36], and BAT has been reported to play an important role in metabolism and sarcopenia [37]. Secondary sarcopenia (disease-related sarcopenia) associated with heart failure [38] has been shown to result in atrophy of slow twitch muscle [39]; in contrast, age-related sarcopenia results in atrophy of fast twitch muscle [40]. The lower level of physical inactivity in heart failure patients may be different from the physical inactivity that occurs with aging or musculoskeletal disease. Although the patient’s ADL may improve while preventing overwork and exacerbation of heart failure, if the total amount of physical activity is extremely low, older adult patients may develop hospitalization-associated disability and have a worse prognosis after discharge. For patients with heart failure, it is considered necessary to first gauge the adequacy of the individual’s capacity for cardiac workload (single continuous period and total duration of activity). Elucidation of this point is considered to be a goal of future research. In older adults with heart failure and subacute musculoskeletal disease, physical activity should be monitored separately from independence in ADL.

Limitations

We used the longest continuous time per hour with an epoch length of a 10-s bout as the single continuous period in the analysis; therefore, the results may differ depending on how the single continuous period is defined. The accuracy of the accelerometer may vary with activity outcomes such as step, type of activity, limb position, and in populations with low mobility. The validity and reliability of non-free-living activities, such as exercises during rehabilitation period, remains unclear. Therefore, researchers should be cautious when applying the activity monitor to new populations or activities where the accuracy of the device has not been specifically tested. One selection bias of this study was that the facility conducting this research was situated within a general hospital. At the time of a scheduled admission or an emergency admission, patients with complex diseases other than musculoskeletal disease may intentionally select a hospital that can provide more comprehensive care. This may have induced bias in participants’ medical history in this study. As for the other medical history (such as chronic obstructive pulmonary disease, liver disease, renal disorder, dementia, and joint disease), it was assumed that a certain number of patients had been diagnosed or had completed or discontinued treatment at other hospitals in the past or had not undergone checkups and had not been diagnosed. Our medical records did not cover this disease entirely; these missing data may have provided the information bias and were not included in the medical history variable. But these diseases are considered to be an urgent issue to be investigated. For physical activity in older adults, environmental factors should also be considered, such as area of residence, facility equipment, family members living together, and their caregiving ability, in addition to individual factors, such as motivation and life history.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Shimizu T, Kanai C. Methodology: Shimizu T, Ueda K, Asakawa Y. Formal analysis: Shimizu T, Asakawa Y. Project administration: Shimizu T, Kanai C. Visualization: Shimizu T. Writing – original draft: Shimizu T, Kanai C. Writing – review and editing: Shimizu T, Ueda K, Asakawa Y. Approval of final manuscript: all authors.

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ORCID

Tomoko Shimizu, https://orcid.org/0009-0006-0532-767X
Chiaki Kanai, https://orcid.org/0009-0007-1306-8505
Keisuke Ueda, https://orcid.org/0009-0000-4104-3208
Yasuyoshi Asakawa, https://orcid.org/0009-0008-4511-1608

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