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Original Article

Relationship between the characteristics of lower extremity function and activities of daily living in hospitalized middle-aged and older adults with subacute cardiovascular disease

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Abstract. [Purpose] To clarify the relationship between lower extremity function and activities of daily living and characterize lower extremity function in hospitalized middle-aged and older adults with subacute cardiovascular disease. [Participants and Methods] The Short Physical Performance Battery, 6-minute walk distance, and functional independence measure tests were conducted in 79 inpatients with subacute cardiovascular disease (mean age, 76.7 ± 11.9 years; 34 females). Multiple regression analysis used the functional independence measure score as the dependent variable and the Short Physical Performance Battery and 6-minute walk distance scores as independent variables. Cross-tabulations were performed for each age group, and patients who performed the Short Physical Performance Battery and 6-minute walk distance tests were divided into two groups by their respective cutoff values. [Results] Only the Short Physical Performance Battery (β=0.568) and 6-minute walk distance (β=0.479) scores were adopted as significant independent variables in each multiple regression model. The age <75 years group had the most patients with both good lower extremity function and aerobic capacity, whereas the age ≥75 years group had the most patients with both functions impaired. [Conclusion] Although cardiovascular disease is generally associated with decreased aerobic capacity, many older patients with cardiovascular disease in this study had decreased lower extremity function, too.

Key words: Lower limb function, Aerobic capacity, Functional limitation

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INTRODUCTION

Cardiovascular disease (CVD) occurs more frequently in older adults and is a major cause of disability and limited activity[1)]. The decreased ability to carry out activities of daily living (ADL) that occurs in patients with CVD is an important factor in their prognosis after discharge from the hospital[2)]. Cardiac rehabilitation beginning within 2 weeks of diagnosis has been shown to be safe and feasible, and has accelerated the initiation of exercise therapy for patients with CVD[3)]. Therefore, the appropriate assessment of and intervention in ADL early in the hospitalization phase is important for treating patients with CVD.

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Aerobic capacity in patients with CVD is an important indicator related to rehospitalization rates, survival, and ADL[4–10]. Therefore, improving aerobic capacity is one of the most common goals of cardiac rehabilitation[11]. With the recent increase in the number of older patients with CVD with frailty[12], the importance of assessing and intervening in lower extremity function, as well as aerobic capacity, is increasing. The Short Physical Performance Battery (SPPB), which consists of the standing balance test, the 4-meter gait speed test (4MGS), and the five-repetition sit-to-stand motion test (5STS), is a comprehensive instrument for assessing lower extremity function that can be measured in a short period of time[13, 14]. The SPPB has been reported to be an excellent predictor of physical activity levels and gait impairment in community-dwelling older adults[13, 14]. It has also been reported to be feasible for safely assessing lower extremity function in patients with CVD during the early phase of hospitalization[15]. Therefore, the SPPB is considered to be a suitable index to assess lower limb function in patients with CVD in the early stage of hospitalization.

However, the relationship between lower extremity function and ADL and the characteristics of lower extremity function in patients with subacute CVD has not been fully investigated. Adding the assessment of lower extremity function to the widely used assessment of aerobic capacity in patients with subacute CVD could contribute to more individualized decision-making for rehabilitation interventions. Given this background, this study aimed to determine the relationship between lower extremity function and ADL and to characterize lower extremity function in hospitalized middle-aged and older adults with subacute CVD.

PARTICIPANTS AND METHODS

Data for this multicenter, cross-sectional observational study were collected from patients with CVD admitted to the general wards of two institutions in Japan that provide cardiovascular surgery and cardiac rehabilitation between June 2020 and January 2022.

This study was approved by the ethics review committees of Ibaraki Prefectural University of Health Sciences (No. 922), the Ethics Committees at Numata Neurosurgery and Cardiovascular Hospital (No. 321), and Fujioka General Hospital (No. 195), and conducted in accordance with the Declaration of Helsinki. All patients gave written informed consent prior to participation. The study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[16].

The initial enrollment included 121 patients who were hospitalized for CVD, had physician permission to measure 6MWD, and were undergoing physical therapy. The exclusion criteria were as follows: unable to walk regardless of walking aids before admission to the hospital; unstable angina; unable to follow instructions because of cognitive decline; and missing records for analytical data.

The patient demographics and clinical characteristics included age, gender, medical history, days from admission and cardiovascular surgery, laboratory parameters, and eight grades (0–7 points) regarding the premorbid degree of bedridden-ness[17]. The New York Heart Association (NYHA)[18] and type of CVD were collected from the patients' medical records. Each evaluation was performed on the same day within 2 weeks prior to discharge by a physical therapist who fully understood the evaluation procedure.

The parts of the SPPB were performed in the following order: (a) the standing balance test; (b) 4MGS; and (c) 5STS[13, 14]. The standing balance test required the participant to maintain his or her stance with their feet placed side-by-side, then semi-tandem, and then in a tandem posture, for 10 seconds each. The 4MGS measures the time required to walk 4 meters at a typical pace. In the 5STS, the participants folded their hands in front of their chest, and the time required to stand up from a seated position five times was measured. Total possible score of 0–12 points. The higher the score, the better the lower limb function. The reliability[19] and validity[20, 21] of the SPPB have been confirmed.

The 6MWD as described in the American Thoracic Society (ATS) guidelines was used to evaluate the participants' aerobic capacity[22]. Due to space limitations, the measurements were taken using a 15-meter indoor walking path. In another study, the 6MWD using 15- and 30-meter walking paths for healthy adults and patients with chronic lung disease showed concordance correlation coefficients of 0.79 and 0.93 and Pearson's correlation coefficients of 0.85 and 0.96, respectively[23]. The 6MWD has demonstrated excellent reliability and validity in patients with CVD[24]. Posttreatment acute myocardial infarction (AMI) was included in this study because of the reported safety of 6MWD measurements for early-onset AMI[25, 26].

The functional independence measure (FIM) was used to assess the performance of ADL[27]. The items on the FIM consist of 13 motor and five cognitive measures. Each item is scored on a scale from 1 to 7, for a total possible score of 18–126. A lower score indicates a lower level of independence in ADL, whereas a higher score indicates a higher level of independence. The reliability[28] and validity[29] of the measurement have been reported.

Descriptive statistics of demographic and clinical characteristics are presented as means and standard deviations for continuous variables and as rates and frequency distributions for categorical data.

To determine the relationships among lower extremity function, aerobic capacity, and ADL, Pearson's product-rate correlation coefficients (r) between the SPPB, 6MWD with demographic and clinical characteristics data, FIM scores were calculated, respectively. In addition, Pearson's product-rate correlation coefficient (r) was calculated to examine the association between the SPPB (sub item, total) and 6MWD. The strength of the coefficient was determined as follows: 0.00 to 0.25

indicated little if any correlation, 0.26 to 0.49 indicated a weak correlation, 0.50 to 0.69 indicated a moderate correlation, 0.70 to 0.89 indicated a strong correlation, and 0.90 to 1.00 indicated a very strong correlation[30].

Next, two multivariate linear regressions (forced entry method) were calculated with the FIM-total score as the dependent variable. Since the correlation coefficient between the SPPB and 6MWD was ≥0.7 based on prior correlation analysis, a multiple regression model was calculated with the SPPB and 6MWD as independent variable, respectively, to account for multicollinearity. Both models were adjusted for age, gender, history of heart disease, premorbid degree of bedriddenness, hemoglobin, and NYHA class. The multicollinearity between each independent variable and covariate was determined by checking the variance inflation factor (VIF), and multicollinearity was considered to be present when the VIF was ≥10[31]. The goodness-of-fit of each model was determined by the coefficient of determination (R^2).

To characterize each patient's lower extremity function and aerobic capacity, both the SPPB and 6MWD were classified into two groups by cutoff values and cross-tabulated. The SPPB was classified into two groups with a cutoff value of SPPB ≤9, which is the diagnostic criterion for sarcopenia in the Asian Working Group for Sarcopenia 2019[32]. The 6MWD classified participants into two groups based on 6MWD <300 meters, which is considered the cutoff value for increased future mortality and recurrence rates in patients with CVD[4, 5]. The difference between each category was calculated using Fisher's exact test. A preliminary correlation analysis showed that both SPPB and 6MWD scores were significantly correlated with age, so we considered the effect of aging and examined each of the two groups (age <75, age ≥75). In the age groups where significant differences were found, FIM scores were compared using one-way analysis of variance (ANOVA), revealing differences in ADL due to the characteristics of lower limb function and aerobic capacity. Tukey's method was used for multiple comparisons.

All statistical analyses were conducted using SPSS Statistics 25.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

RESULTS

Figure 1 shows a flowchart of the patient inclusion process. Of the 121 inpatients with subacute CVD who met the inclusion criteria, 79 were included in the analysis. Table 1 shows the participants' clinical characteristics. Cardiac function was preserved in most patients, and heart failure was the most common type of CVD.

Table 2 shows the bivariate correlations among the SPPB, 6MWD, clinical characteristics, and FIM. Both the SPPB and 6MWD showed significant correlations with age, NYHA class, premorbid degree of bedriddenness, FIM-motor, and FIM-total, all with similar effect sizes. The results of the correlation analysis between the SPPB and 6MWD showed significant positive correlations with standing balance ($r=0.551$, $p<0.001$), 4MGS ($r=0.676$, $p<0.001$), 5STS ($r=0.568$, $p<0.001$), and total ($r=0.709$, $p<0.001$). Table 3 shows the results of the multivariate linear regression (forced entry method) with FIM as the dependent variable. Only the SPPB and 6MWD were adopted as significant independent variables in each model.

Table 4 shows the results of classification by cutoff values for the SPPB and 6MWD stratified by age. The age ≥75 group showed a significant difference, with the largest proportion of the group having a decline in both lower extremity function and aerobic capacity.

Table 5 shows the differences in ADL by characteristics of lower extremity function and aerobic capacity for the age ≥75 group. The results of the one-way ANOVA showed significant differences between groups ($p=0.002$). Multiple comparisons revealed that the group with impaired lower extremity function and aerobic capacity had significantly lower FIM scores than did the group with good function in both.

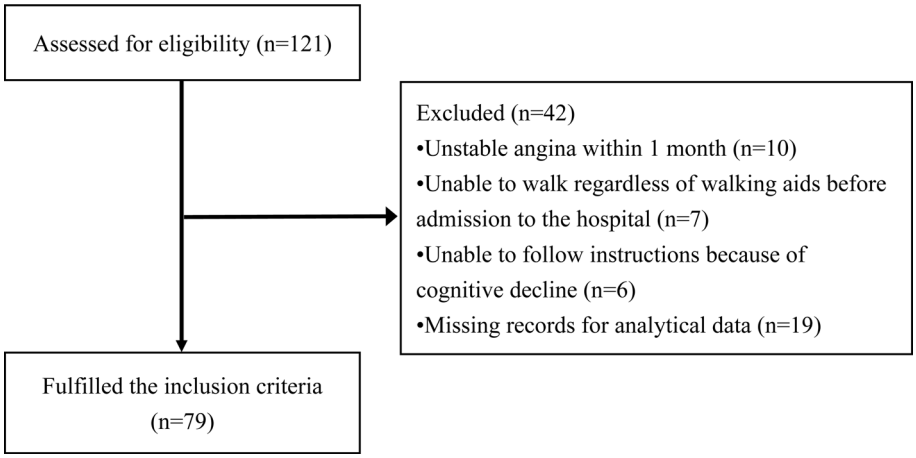

Fig. 1. Flowchart of the patient inclusion process.

Table 1. Clinical characteristics of the participants (n=79)

Variables	
Age (years), mean (SD)	76.7 (11.9)
Gender (females), n (%)	34 (43.0)
History of heart disease, n (%)	46 (58.2)
Days from admission (days), mean (SD)[a]	12.3 (7.4)
Days from cardiovascular surgery (days), mean (SD)[b]	12.8 (9.7)
Laboratory parameters, mean (SD)	
LVEF (%)	53.4 (14.2)
Albumin (g/dL)	3.7 (0.4)
Hemoglobin (g/dL)	12.5 (2.1)
Creatinine (m/dL)	1.5 (1.3)
eGFR (mL/min/1.73 m^2)	57.3 (91.2)
NYHA class (I/II/III), n	42/26/11
Premorbid degree of bedriddenness (points), mean (SD)	1.2 (1.6)
Type of cardiovascular disease, n (%)	
HF	47 (59.5)
AMI	14 (17.7)
VR	3 (3.8)
LVD	8 (10.1)
PMI	7 (8.9)
FIM-motor (points), mean (SD)	76.3 (16.2)
FIM-total (points), mean (SD)	108.8 (18.5)
SPPB (points), mean (SD)	9.5 (2.8)
6MWD (m), mean (SD)	292.5 (110.8)

[a]HF was shown as days from admission, [b]other cardiovascular disease was shown as days from cardiovascular surgery.
AMI: acute myocardial infarction; eGFR: estimated glomerular filtration rate; FIM: functional independence measure; HF: heart failure; LVD: large vessel disease; LVEF: left ventricular ejection fraction; NYHA class: New York Heart Association functional classification; PMI: pacemaker implantation; SD: standard deviation; 6MWD: 6-minute walk distance; SPPB: short physical performance battery; VR: valve replacement.

Table 2. Bivariate correlations between short physical performance battery, 6-minute walk distance and clinical characteristics

	SPPB	6MWD
Age	−0.518**	−0.648**
LVEF	−0.050	−0.092
Albumin	0.098	0.221
Hemoglobin	0.147	0.395**
Creatinine	−0.027	−0.206
eGFR	−0.199	−0.065
NYHA class	−0.328**	−0.472**
Premorbid degree of bedriddenness	−0.438**	−0.468**
FIM-motor	0.597**	0.496**
FIM-total	0.619**	0.522**

**p<0.01.
eGFR: estimated glomerular filtration rate; FIM: functional independence measure; LVEF: left ventricular ejection fraction; NYHA class: New York Heart Association functional classification; 6MWD: 6-minute walk distance; SPPB: short physical performance battery.

Table 3. Multivariate linear regression (forced entry method) with functional independence measure as dependent variable and short physical performance battery and 6-minute walk distance as each independent variables

	Model SPPB			Model 6MWD		
	β	p value	VIF	β	p value	VIF
Age	0.021		1.730	−0.009		1.881
Gender						
Females	Reference	-	-	Reference	-	-
Males	0.126		1.275	0.150		1.294
History of heart disease	0.025		1.126	0.003		1.135
Premorbid degree of bedriddenness	−0.167		1.376	−0.230		1.343
Hemoglobin	0.125		1.264	−0.001		1.300
NYHA	−0.031		1.221	0.018		1.340
SPPB	0.568	**	1.579	-	-	-
6MWD	-	-	-	0.479	**	2.319
R^2	0.429			0.323		
adjusted R	0.372			0.257		

**p<0.01.
NYHA class: New York Heart Association functional classification; 6MWD: 6-minute walk distance; SPPB: short physical performance battery; VIF: variance inflation factor.

Table 4. Classification by cutoff values for short physical performance battery and 6-minute walk distance stratified by age

Variables[a]		SPPB ≤9	SPPB >9	p-value[b]
Age <75 group (n=27)	6MWD <300 m	1 (3.7)	3 (11.1)	
	6MWD ≥300 m	3 (11.1)	20 (74.1)	
Age ≥75 group (n=52)	6MWD <300 m	25 (48.1)	9 (17.3)	**
	6MWD ≥300 m	3 (5.8)	15 (28.8)	

[a]Data presented as n (%), [b]the p values were computed by Fisher's exact test.
**p<0.01.
6MWD: 6-minute walk distance; SPPB: short physical performance battery.

Table 5. Differences in FIM score compared by lower extremity function and aerobic capacity characteristics in Age ≥75 group

Variables[a]	FIM score
SPPB ≤9 and 6MWD <300 m group (n=25)	97.6 (19.2)**
SPPB >9 and 6MWD <300 m group (n=9)	111.6 (7.9)
SPPB ≤9 and 6MWD ≥300 m group (n=3)	109.3 (12.2)
SPPB >9 and 6MWD ≥300 m group (n=15)	116.7 (8.1)

[a]Data presented as mean (SD), [b] **p<0.01 (Multiple comparison by Tukey method with SPPB >9 and 6MWD ≥300 m group).
6MWD: 6-minute walk distance; FIM: functional independence measure; SPPB: short physical performance battery.

DISCUSSION

This multicenter, cross-sectional, observational study aimed to determine the relationship between lower extremity function and ADL and to characterize lower extremity function in middle-aged and older adults hospitalized with subacute CVD. The results showed that both lower extremity function and aerobic capacity were associated with ADL to the same degree. In addition, an increasing number of cases of lower limb function were found in the older adults, and the older adults with reduced lower limb function and aerobic capacity were found to have significantly lower ADL compared with the other groups.

The FIM is a composite index that evaluates dressing, toileting, stair climbing, and other activities that require a high degree of static and dynamic balance and mobility. The SPPB includes tasks such as standing balance, getting up from a chair, and mobility, and consists of actions that are frequently required in actual ADL[13, 14]. In fact, the incidence of ADL impairment has been reported to be higher among community-dwelling older adults with a low SPPB than among those with a high SPPB[13, 20], which is consistent with the present results. The present findings suggest the usefulness of the SPPB for assessment and intervention decision-making in improving ADL, including balance and mobility. The 6MWD has been

reported to be significantly associated with ADL difficulty in patients with CVD undergoing outpatient rehabilitation[9]; the results of the present study indicate that ADL is also significantly associated with the 6MWD in middle-aged and older adults hospitalized with subacute CVD.

Comparing both models by using multiple regression analysis, the SPPB and 6MWD had roughly similar contribution rates to ADL. However, classification by cutoff values stratified by age identified cases with a decrease in only aerobic capacity or lower extremity function. In patients with heart failure, the SPPB and 6MWD have been reported to differ in their ability to predict cardiovascular event rates[33], mortality[10], and disease recurrence[10]. Therefore, the SPPB and 6MWD assess different functions, and the results of this study, in which there were cases with conflicting functions between the two, are consistent. These findings suggest that assessing lower extremity function in addition to aerobic capacity, which is commonly used in CVD, contributes to a more individualized selection of rehabilitation intervention strategies in middle-aged and older adults hospitalized with subacute CVD.

This study had several limitations. Only patients who could participate in the 6MWD were included, and the majority of participants had mild disease. In fact, the NYHA class was not adopted as a significant independent variable in either model in the multiple regression analysis. Moreover, cardiac function, similar to age and premorbid function, is a factor of concern because of its impact on performance. The results of this study should therefore be interpreted in light of these limitations.

The results are expected to contribute to the improved care of frequently occurring CVD in older adults as well as the selection of more individualized intervention strategies for rehabilitation.

Funding and Conflict of interest

None.

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