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Original Article

Influence of Physical Characteristics on Readmission in Older Cardiac Patients

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ABSTRACT

Background/Purpose: The aim of this study was to compare the influence of physical characteristics using consensus-based criteria on readmission in older cardiac patients.

Methods: This retrospective cohort study included 70 cardiac patients (mean age, 78.4 years; 42.9% women). We investigated the incidence of readmission 1 year from hospital discharge. Physical characteristics were evaluated the presence of sarcopenia, low muscle mass, low physical function, and low physical performance, respectively. Sarcopenia, low muscle mass and low physical function were defined with reference to the Asian Working Group for Sarcopenia-suggested diagnostic algorithm. Low physical performance was defined as a short physical performance battery score of less than 10 points. Cox proportional hazard models were used to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs) of the relationships between the presence of various physical characteristics and the time to readmission in univariate and multivariate analyses, respectively.

Results: The incidence of readmission was 22.9%. The adjusted HR (95% CI) was 2.59 (0.73-9.14), 1.29 (0.36-4.68), 4.81 (1.06-21.85), and 12.76 (2.61-62.45) in patients with sarcopenia, low muscle mass, low physical function, and low physical performance, respectively.

Conclusion: Although this is the discovery as a pilot study, the risk of readmission in older cardiac patients with low physical function or performance might be higher than that in these patients with normal physical function or performance, regardless of muscle mass.

1. INTRODUCTION

Careful observation that physical characteristics, such as muscle mass, muscle strength, and physical performance, are more likely decreased in older cardiac patients is necessary. Particularly, many cardiac

patients are elderly persons,[1,2] and focusing on the physical characteristics for cardiac older patients is significant. Several studies reported that the physical characteristics of older cardiac patients were lower than older adults without cardiac diseases.[3-5] Lower physical characteristics lead to adverse health outcomes, such as disability and death.[6-8] Therefore, poor prognosis due to the deterioration of physical characteristics in older cardiac patients is possible.

Actually, several studies reported that decreased physical characteristics were associated with poor prognosis in cardiac patients. For example, sarcopenia, defined as low skeletal muscle mass and low skeletal muscle function, is one of the causes of adverse outcome in cardiac patients.[9] Furthermore, muscle strength and physical performance are important prognostic factors in cardiac patients.[10,11] Therefore, evaluation of physical characteristics is important when considering the prognosis of cardiac patients.

Older cardiac patients frequently experience hospital readmissions due to adverse events, and consideration of a preventive strategy is necessary.[12,13] Readmissions have a risk for cardiac dysfunction.[14] In addition, heart disease-related readmissions are one of the major causes of increased medical fees.[15] Furthermore, hospitalization accelerates decreased physical characteristics due to bed rest, inflammation, and malnutrition.[16] Because of these causes for hospital-associated disability,[17,18] prevention of physical functional deterioration during hospitalization is necessary. Lower physical characteristics are recently suggested as a factor affecting readmission.[19] However, which physical characteristic indicators affects readmission in older cardiac patients more is still unclear.

We hypothesized that the indicators, such as physical performance, including several physical elements (e.g. muscle strength, joint mobility, subtle neurological factors)[20,21] are associated with readmission to a greater extent. The aim of this study was to compare the influence of physical characteristics using consensus-based criteria on readmission in older cardiac patients.

2. METHODS

2.1. Study Design and Participants

This retrospective cohort study was conducted in patients with emergency admission due to heart disease in the Kawasaki Municipal Tama Hospital. These baseline data were investigated at discharge from April 2015 to March 2016. The inclusion criteria were age 65 years or older and the ability to ambulate a few meters without physical assistance. The exclusion criteria were patients with cardiovascular implantable electronic devices (because these patents did not allow to receive bioelectrical impedance), being on a waiting list for any invasive cardiac procedure, not Japanese, and missing of baseline data. The present study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Committee on Human Research of St. Marianna University School of Medicine.

2.2. Study Outcome

The study patients were followed up at one year from hospital discharge. The study outcome was readmission during the follow-up period.[22] Readmission was defined as an episode of emergency hospitalization lasting >24 h, except for elective hospitalization for medical examination. In addition, the time to the first readmission was investigated. Data on study outcomes were collected through medical records.

2.3. Physical Characteristics

Physical characteristics were represented by four classification methods. We investigated presence of sarcopenia, low muscle mass, low physical function, and low physical performance, respectively. Sarcopenia, low muscle mass and low physical function were defined with reference to the Asian Working Group for Sarcopenia-suggested diagnostic algorithm.[23] Skeletal muscle mass was measured by bioelectrical impedance analysis, and the appendicular muscle mass was converted into the skeletal muscle mass index (SMI). Low muscle mass was defined as SMI <7.0 kg/m^2 and <5.7 kg/m^2 in men and women, respectively. Low physical function was defined as low handgrip strength (<26 kg for men and <18 kg for women) and/or low usual gait speed (<0.8 m/s). Handgrip strength was measured by using a standard adjustable-handle JAMAR dynamometer (Bissell Healthcare Co., Grand Rapids, MI). The patients squeezed the dynamometer at the second grip position with their dominant hand at maximum isometric effort. The higher value from the two measurements was used as the representative value of handgrip strength. Usual gait speed was measured in a 5-m course. The patients walked 11 m at their usual pace. The time required to walk 5 m (between the 3 m and 8 m points) was measured using a stopwatch. Usual gait speed was calculated as 5 m divided by time required (m/s). The higher value of the two measurements was used as the representative value of usual gait speed. Sarcopenia was defined as the presence of both low muscle mass and low physical function. Physical performance was measured using the short physical performance battery (SPPB). Low physical performance was defined as an SPPB score of less than 10 points by the previous study.[24] For these variables, we used the values measured at discharge.

2.4. Demographic and Clinical Characteristics

We investigated demographic and clinical characteristics, including cohabitation, participation in outpatient rehabilitation during follow-up, cardiac conditions, serum laboratory measurements, comorbidity, body composition, and cognitive function. Outpatient rehabilitation consisted of stretching, resistance exercise, and aerobic exercise, monitored by physical therapists. In addition, this rehabilitation program included advice on self-monitoring of blood pressure and body weight by physical therapists. The exercise intensity was moderate (11 to 13 on the Borg scale) for both resistance and aerobic exercise.[25,26] The exercise program consisted of 20 minutes of upper and lower limb resistance exercise and 20 minutes of cycle ergometer training or treadmill walking as aerobic exercise, respectively. The total duration of each outpatient rehabilitation session was about an hour. Rehabilitation sessions were held once a week for 5 months. Cardiac conditions were investigated, including admission diagnosis, type, and etiology of heart failure, medications, New York Heart Association (NYHA) classification, and left ventricular ejection fraction (LVEF). Admission diagnosis was defined by the International Statistical Classification of Diseases, 10th Revision codes, and we investigated heart failure (I50), myocardial infarction (I21) and angina pectoris (I20). Types of heart failure were assigned to heart failure with reduced ejection fraction (HFrEF), heart failure with preserved ejection fraction (HFpEF), and HFpEF borderline, based on the American College of Cardiology Foundation/American Heart Association Guidelines.[27] Brain natriuretic peptide (BNP), creatinine, and hemoglobin concentrations were also investigated. Comorbidities, such as presence of medical disease, and the Charlson comorbidity index[28] were also investigated. Extracellular water-to-total body water (ECW/TBW) ratio measured using bioelectrical impedance analysis, and presence of increased fluid status (ECW/TBW >0.400) were also investigated.[29] Cognitive function was assessed using the Revised Hasegawa's Dementia Scale (HDS-R).[30]

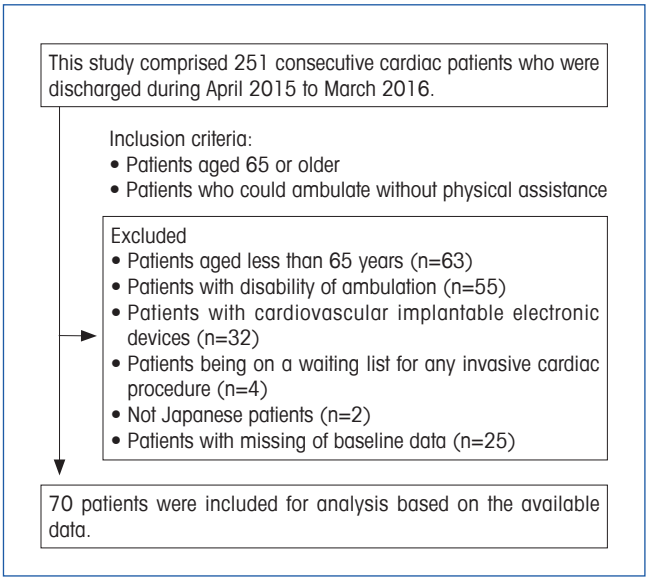
2.5. Statistical Analysis

We compared patient characteristics based on readmission during the follow-up period. Unpaired t-tests, Mann–Whitney U tests, or Chi-squared tests were used to test for differences between the two groups after evaluating normality of variables with Shapiro-Wilk tests. Cox proportional hazard models were used to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs) of the relationships between the presence of various physical characteristics (sarcopenia, low muscle mass, low physical function, and low physical performance) and the time to readmission in univariate and multivariate analyses. For the multivariate analysis, we included age, NYHA classification, and creatinine as covariates in reference to the literature.[13,30] Covariates with normality were dealt with continuous variables, and these without normality were dealt with quartile determining the lowest as reference. In addition, NYHA classification as a covariate was dealt with class I as reference. We also compared the time to readmission based on the presence of various physical characteristics, using Kaplan–Meier survival curves and log-rank tests. Statistical significance was defined as $p < 0.05$ for all analyses. Statistical analyses were performed with SPSS (version 21, IBM SPSS Japan, Tokyo, Japan).

3. RESULTS

Of the 251 potential patients, 70 patients were included for analysis based on the inclusion and exclusion criteria in the present study (Figure. 1). The mean (standard deviation) age of these patients was 78.4 years (7.9 years), and 42.9% were women. Admission diagnoses were heart failure (n=47, 67.1%) and acute coronary syndrome (n=23, 32.9%).

Figure 1. Diagram of the patient selection process.



The incidence of readmission during the 1-year follow-up period was 22.9%. The causes of readmission were heart failure (n=12, 68.8%), infection (n=2, 12.5%), renal failure (n=1, 6.3%), dehydration (n=1, 6.3%), and gastrointestinal disease (n=1, 6.3%). The presence of each physical characteristics, such as sarcopenia (n=27, 38.6%), low muscle mass (n=45, 64.3%), low physical function (n=34, 48.6%), and low physical performance (n=22, 31.4%), were also evaluated.

Comparisons of patient characteristics based on readmission are shown in Table 1. With regard to physical characteristics, the presence of sarcopenia, low physical function, and low physical performance was significantly higher in patients who were readmitted ($p < 0.05$). Furthermore, significant differences were observed between the two groups

Table 1. Patients characteristics.

	Overall (n=70)	Patients with Readmission (n=16)	Patients without Readmission (n=54)	P value
Age, mean±SD	78.4±7.9	83.1±6.6	77.1±7.8	0.006[a]
Gender				0.622[b]
Men, n (%)	40 (57.1%)	10 (62.5%)	30 (55.6%)	
Women, n (%)	30 (42.9%)	6 (37.5%)	24 (44.4%)	
Cohabitation				0.174[b]
Alone, n (%)	17 (24.3%)	4 (25.0%)	13 (24.1%)	
Family, n (%)	50 (71.4%)	10 (62.5%)	40 (74.1%)	
Nursing home n, (%)	3 (4.3%)	2 (12.5%)	1 (1.9%)	
Participation in outpatient rehabilitation, n (%)	6 (8.6%)	3 (18.8%)	3 (5.6%)	0.098[b]
Sarcopenia, n (%)	27 (38.6%)	10 (62.8%)	17 (31.5%)	0.025[b]
SMI [kg/m^2], mean±SD	6.11±1.18	5.91±1.28	6.17±1.15	0.432[a]
Low muscle mass, n (%)	45 (64.3%)	12 (75.0%)	33 (61.1%)	0.309[b]
Handgrip strength [kg], median (IQR)	23.2 (16.8-30.9)	21.3 (17.3-25.3)	25.0 (16.8-31.9)	0.240[c]
Gait speed [m/sec], mean±SD	0.93±0.25	0.77±0.22	0.98±0.24	0.004[a]
Low physical function, n (%)	34 (48.6%)	13 (81.3%)	21 (38.9%)	0.003[b]
SPPB score, median (IQR)	11.0 (8.0-12.0)	8.0 (6.5-9.0)	11.0 (10.0-12.0)	<0.001[c]
Low physical performance <10, n (%)	22 (31.4%)	12 (75.0%)	10 (18.5%)	<0.001[b]
Admission diagnosis				0.171[b]
Heart failure, n (%)	47 (67.1%)	13 (81.3%)	34 (63.0%)	
Acute coronary syndrome, n (%)	23 (32.9%)	3 (18.8%)	20 (37.0%)	
Etiology of heart failure, n=47				0.521[b]
Ischemic heart disease, n (%)	9 (12.9%)	3 (23.1%)	6 (17.6%)	
Cardiomyopathy, n (%)	7 (10.0%)	2 (15.4%)	5 (14.7%)	
Valvular disease, n (%)	19 (27.1%)	7 (53.8%)	12 (35.3%)	
Arrythmia, n (%)	11 (15.7%)	1 (7.7%)	10 (29.4%)	
Pulmonary hypertension, n (%)	1 (1.4%)	0 (0%)	1 (2.9%)	
Type of heart failure				0.901[b]
HFrEF, n (%)	12 (17.1%)	3 (18.8%)	9 (16.7%)	
HFpEF, n (%)	51 (72.9%)	11 (68.8%)	40 (74.1%)	
HFpEF borderline, n (%)	7 (10.0%)	2 (12.5%)	5 (9.3%)	
Medications				
Beta-blockers, n (%)	64 (91.4%)	15 (93.8%)	49 (90.7%)	0.706[b]
ARB/ACE-I, n (%)	53 (75.3%)	10 (62.5%)	43 (79.6%)	0.160[b]
CCB, n (%)	22 (31.4%)	8 (50.0%)	14 (25.9%)	0.068[b]
Diuretic, n (%)	50 (71.4%)	16 (100.0%)	34 (63.0%)	0.004[b]
NYHA classification				0.017[b]
Class I, n (%)	19 (27.1%)	1 (6.3%)	18 (33.3%)	
Class II, n (%)	33 (47.1%)	7 (43.8%)	26 (48.1%)	
Class III, n (%)	18 (25.7%)	8 (50.0%)	10 (18.5%)	
LVEF [%], median (IQR)	60.5 (46.0-70.0)	61.0 (42.5-65.5)	60.0 (49.0-70.0)	0.716[c]
LVEF ≤45%, n (%)	17 (24.3%)	5 (31.3%)	12 (22.2%)	0.460[b]
Laboratory measures in serum				
BNP, [pg/ml], median (IQR)	287.5 (95.6-544.0)	587.0 (342.0-823.5)	232.0 (68.5-457.0)	0.002[c]
Creatinine [mg/dL], median (IQR)	0.93 (0.79-1.18)	1.15 (0.89-1.57)	0.89 (0.77-1.06)	0.019[c]
Hemoglobin [g/dL], mean±SD	11.8±1.8	11.3±1.6	12.0±1.8	0.169[a]
Comorbidity				
Hypertension, n (%)	36 (51.4%)	8 (50.0%)	28 (51.9%)	0.896[b]
Dyslipidemia, n (%)	25 (35.7%)	3 (18.8%)	22 (40.7%)	0.107[b]
COPD, n (%)	4 (5.7%)	2 (12.5%)	2 (3.7%)	0.183[b]
Diabetes, n (%)	17 (24.3%)	5 (31.3%)	12 (22.2%)	0.460[b]
CKD, n (%)	10 (14.3%)	4 (25.0%)	6 (11.1%)	0.163[b]
Charlson comorbidity index, median (IQR)	2.0 (1.0-2.0)	2.0 (2.0-3.5)	2.0 (1.0-2.0)	0.024[c]
BMI [kg/m^2], mean±SD	21.4±3.2	20.7±4.1	21.5±2.9	0.473[a]
Underweight <18.5, n (%)	14 (20.0%)	5 (31.3%)	9 (16.7%)	0.351[b]
Normal 18.5-24.9, n (%)	45 (64.3%)	8 (50.0%)	37 (68.5%)	
Obesity ≥25.0, n (%)	11 (15.7%)	3 (18.8%)	8 (14.8%)	
ECW/TBW, mean±SD	0.400±0.104	0.407±0.117	0.397±0.09	0.001[a]
Increased fluid status >0.400, n (%)	32 (45.7%)	12 (75.0%)	20 (37.0%)	0.007[b]
HDS-R, median (IQR)	25.0 (23.0-27.0)	23.5 (18.0-25.5)	26.0 (24.0-28.0)	0.019[c]

SD, standard deviation; IQR, interquartile range; SPPB, short physical performance battery; BMI, body mass index; SMI, skeletal muscle mass index; HFrEF, heart failure with reduced ejection fraction; HFpEF, heart failure with preserved ejection fraction; ARB, angiotensin receptor blocker; ACE-I, angiotensin converting enzyme inhibitor; CCB, calcium channel blocker; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; BNP, brain natriuretic peptide; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; ECW, extracellular water; TBW, total body water; HDS-R, Revised Hasegawa's Dementia Scale.
[a]P values for unpaired t-tests; [b]P values for chi-squared tests; [c]P values for Mann-Whitney U tests.

for age, diuretic intake, NYHA classification, BNP, creatinine, Charlson comorbidity index, ECW/TBW, and HDS-R ($p < 0.05$).

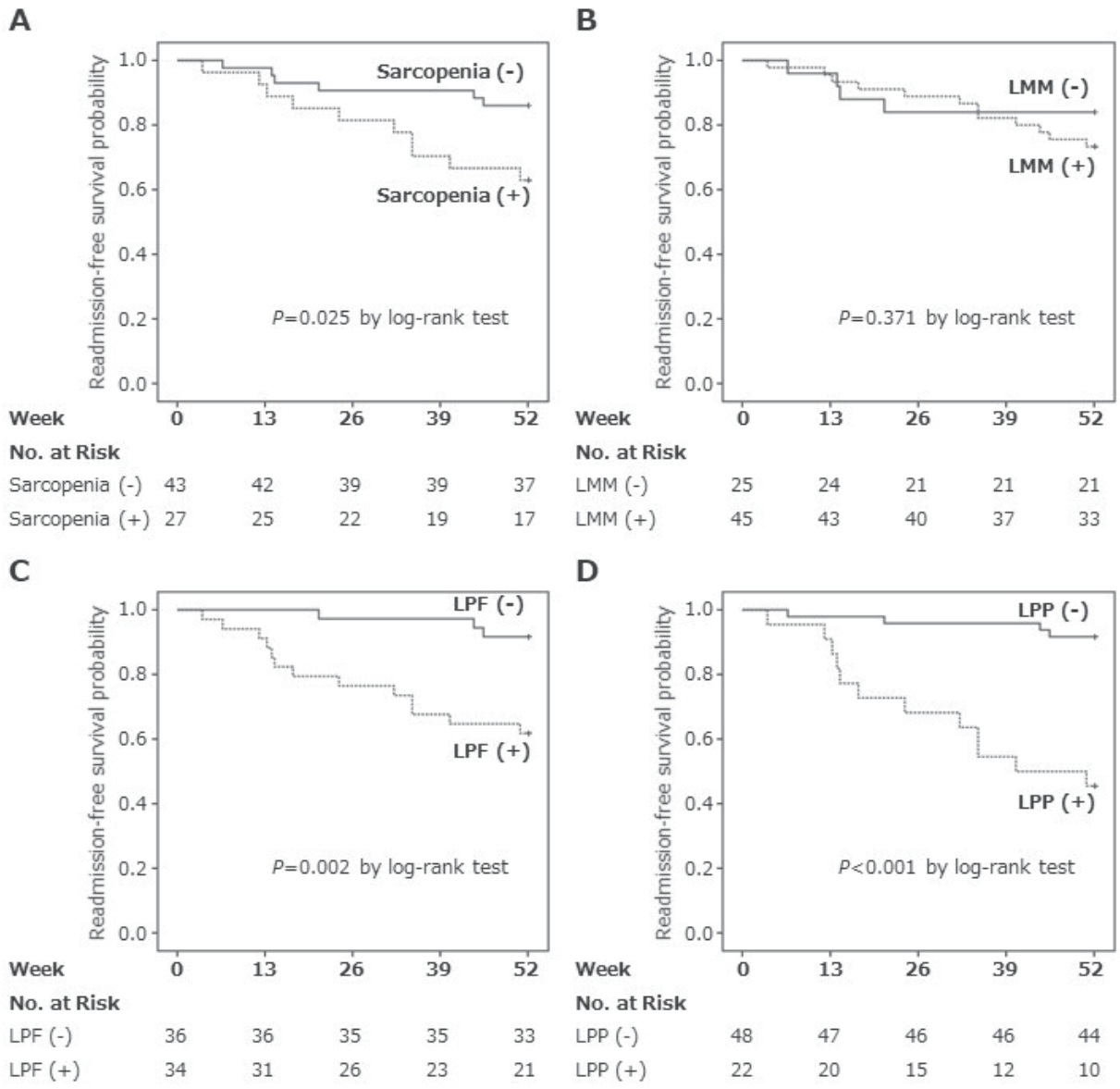
The results of Cox proportional hazard models in various physical characteristics for prediction of readmission are shown in Table 2. Furthermore,

Table 2. Comparisons of physical characteristics for prediction of readmission.

	Univariate Analyses			Multivariate Analyses		
	HR	95% CI	P value	HR	95% CI	P value
Sarcopenia	3.00	1.09-8.28	0.033	2.59	0.73-9.14	0.140
Low muscle mass	1.67	0.54-5.17	0.377	1.29	0.36-4.68	0.694
Low physical function	5.70	1.62-20.02	0.007	4.81	1.06-21.85	0.042
Low physical performance	8.98	2.88-27.98	<0.001	12.76	2.61-62.45	0.002

Cox proportional hazards models: multivariate analyses are adjusted for age (continuous), NYHA classification, serum creatinine level (quartile). HR, hazard ratio; CI, confidence interval; NYHA, New York Heart Association.

Figure 2. Kaplan-Meier survival curves for readmission are presented for each group according to their types of division by physical characteristics.



Patients with sarcopenia (A), LPF (C), and LPP (D) were more likely to be readmission than absence of each status in the univariate analyses ($p < 0.05$). In the multivariate analyses, patients with LPF (adjusted HR: 4.81) and LPP (adjusted HR: 12.76) were more likely to be readmission than absence of each status ($p < 0.05$). There were no significant differences for incidence of readmission according to the presence or absence of LMM in univariate and multivariate analyses (B).

the Kaplan–Meier survival curves based on the presence of each physical characteristic are shown in Figure 2. In the univariate analysis, sarcopenia, low physical function, and low physical performance were significantly associated with risk of readmission ($p < 0.05$). After adjusting for age, NYHA classification, and creatinine, the presence of low physical function and low physical performance were significantly associated with risk for readmission ($p < 0.05$), and the HRs (95% CIs) for low physical function and low physical performance were 4.81 (1.06-21.85) and 12.76 (2.61-62.45), respectively.

4. DISCUSSION

The main finding of this study was that the risk of readmission in patients with low physical function or performance was significantly higher than that in patients with normal physical function or performance regardless of muscle mass. Furthermore, low physical function or performance was associated with readmission after adjustment for several variables that have been shown to have a relationship to readmission in the literature. However, these findings were limited to the discovery as a pilot study because of several limitations.

These findings supported the trend reported in the literature. In the studies that investigated the relationship between readmission and physical indicators,[19,32] slow gait speed and lower SPPB score led to readmission in cardiac patients. The results of our study also showed a tendency to affect readmission in the indicators, including gait speed, such as physical function and physical performance. Furthermore, the SPPB score was a powerful predictor of readmission. Because these indicators were more related to readmission than muscle mass, evaluating both physical function and physical performance in cardiac patients is considered to be important.

The reason why low physical function or performance was more related to readmission might be due to the influence of dynapenia. Dynapenia is the age-associated loss of muscle strength that is not caused by neurologic or muscular diseases.[33] Dynapenia has been reported to decrease muscle strength and physical performance, even though muscle mass is preserved, because muscle quality worsens similar to that of sarcopenia.[34] In addition, dynapenia strongly leads to disability,[35] one of the related factors of readmission.[36] On the other hand, sarcopenia is also reported as an important cause of adverse outcome in cardiac patients.[9] In our study, most of patients with low physical function (79.4%) and performance (81.8%) were sarcopenic. Therefore, the results of our study showed that accurate prognostic predictions could be made by considering patients with dynapenia as high risk in addition to patients with sarcopenia whose main characteristic was reduced muscle mass. Because low physical function or performance reflected this status, these indicators were considered to be more related to readmissions.

In contrast, the reason why only low muscle mass was not significantly related to readmission might be that the proportion of patients with low muscle mass but maintaining physical function was higher in this study. 40% of patients with low muscle mass maintained their grip strength and gait speed. This proportion was higher than the community-dwelling older adults (31.9%) in a previous study.[34] It has been reported that the muscle quality in subjects with these conditions is preserved.[34] Furthermore, low muscle quality might lead to adverse health outcomes.[37] Therefore, patients with low muscle mass in this study might include patients with relatively better prognosis because of preserved muscle quality. In addition, these results might also be influenced by the relatively lower proportion of type I muscle fibers in cardiac patients such as those with heart failure.[38]

This study has both strengths and limitations. The strength of this study was to simultaneously evaluate several physical characteristics using consensus-based criteria and to compare the influence of these characteristics on readmission. From these findings, the physical indicator that should be emphasized for prevention of readmission was clarified. In contrast, this study has several limitations. First, this study was conducted at a single facility, comprising a relatively small sample size. Therefore, this study may generate some concern regarding its statistical power, and we could not completely consider the suspected confounders in the multivariate analyses. In addition, we could not analyze each cause of readmission or type of heart disease, and this study had a particular difficulty in predicting hospitalization in non-heart failure patients and predicting non-cardiovascular hospitalizations. Second, we could not evaluate the confounders associated with disease management, such as medication adherence, nutritional status, and physical activity.[39] Therefore, future studies considering these variables are warranted. Third, the patients with increased fluid status (ECW/TBW >0.400) represented 45.7% of the total sample. Thus, the evaluation of physical characteristics such as sarcopenia and low muscle mass might be affected by overestimation of muscle mass with increased fluid status. Finally, we could not follow-up cognitive function. Cognitive impairment was reported as a factor that affects adverse events, including hospitalization, because it reduces treatment adherence.[40,41] In addition, time-dependent changes of cognitive function have been reported to vary based on the physical characteristics.[42] Therefore, cognitive decline after discharge might have been involved in the results of this study, but this relationship could not be demonstrated. For these limitations, when applying the finding of this study to

clinical practice, it should be noted that this finding is limited to the information as auxiliary reference material.

5. CONCLUSION

Although this is the discovery as a pilot study with limited data, the risk of readmission in older cardiac patients with low physical function or performance regardless of muscle mass might be higher than that in these patients with normal physical function or performance. Therefore, interventions improving physical function or performance to prevent readmission in older cardiac patients might be effective.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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