Original Article

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Coexistence of Non-Lower Body Mass Index and Exercise Habits Reduce Readmission in Older Patients With Heart Failure

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Objective: To investigate the impact of body mass index (BMI) and exercise habits on readmission rates among older patients with heart failure.
Methods: Ninety-seven older patients admitted for heart failure (median age: 81 years; 57.7% male) were included in the study. Patients were categorized into four groups based on the presence or absence of lower BMI and/or the absence of exercise habits. Lower BMI was defined as BMI<20.3 kg/m^2 at discharge and exercise habits were defined as engaging in 30 or more minutes of moderate or vigorous exercise at least once a week. The primary outcome was all-cause readmission during the 1-year follow-up period.
Results: The patients were distributed across four groups: lower BMI/non-exerciser (n=24, 24.7%), lower BMI/exerciser (n=22, 22.7%), non-lower BMI/non-exerciser (n=21, 21.6%), and non-lower BMI/exerciser (n=30, 30.9%). Forty-six patients (47.4%) experienced readmission during the 1-year follow-up period. In a cox proportional hazard analysis, non-lower BMI/exerciser remained an independent prognostic factor even after adjusting for confounding factors (non-lower BMI/exerciser vs. lower BMI/non-exerciser: hazard ratio, 0.26; 95% confidence interval, 0.08–0.83; p=0.022).
Conclusion: The coexistence of non-lower BMI and regular exercise habits may reduce readmission during the 1-year in older patients with heart failure. Therefore, it is imperative to conduct appropriate nutritional assessments for patients with lower BMI at discharge. Additionally, promoting and monitoring sustained physical activity after discharge is crucial for older patients with heart failure.

Keywords: Cardiovascular diseases, Body weights and measures, Physical activity, Hospitalization

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INTRODUCTION

The pandemic of heart failure has emerged as a serious global concern. The number of older people in Japan is increasing, and consequently, the number of heart failure patients is on the rise. Specifically, the count of Japanese outpatients with heart failure was 979,000 in 2005, and it is anticipated to steadily escalate as the population ages, reaching 1.3 million by 2030 [1]. The demographic of heart failure patients is also aging. There has been an absolute increase in the mean age of Japanese heart failure patients, from 71.6 years in 2007 to 77.0 years in 2015 [2]. We are being urged to implement measures in response to the aging of heart failure patients.

The readmission rates for worsening heart failure within one year for Japanese patients with heart failure is 35% [3]. Moreover, it has been reported that readmissions accelerated the escalation of healthcare expenditures [4]. Therefore, preventing readmission in heart failure patients is of paramount importance.

Body mass index (BMI) and exercise habits are important factors associated with readmission in heart failure patients. Lower BMI is associated with worse prognosis, and this phenomenon has also been reported in Japanese heart failure patients [5]. Additionally, maintaining exercise habits has been found to decrease readmission rates [6].

Patients with non-lower BMI and regular exercise habits are expected to have a better prognosis. However, even with a non-lower BMI, the absence of exercise habits may lead to a poorer prognosis. The potential synergistic effect between non-lower BMI and exercise habits, which could further improve readmission rates, has not been fully explored. Therefore, the purpose of this study was to examine the impact of BMI and exercise habits on readmission in older patients with heart failure.

METHODS

Study design and patient population

This study employed a single-center, prospective observational design. The patients consisted of individuals admitted to the Department of Cardiovascular Medicine at the hospital for treatment of acute decompensated heart failure. Inclusion criteria were: (1) age 65 years or older and (2) meeting Framingham criteria. Exclusion criteria were: (1) death during hospitalization; (2) death within 1 year after hospital discharge; and (3) non-response to the questionnaire.

This study was conducted in compliance with the "Declaration of Helsinki" and "Ethical Guidelines for Medical Research Involving Human Subjects." The study protocol underwent review and approval by the Ethical Review Board of Odawara Municipal Hospital (approval no. 2020-18). Informed consent was obtained from each patient, and they were given the option to decline participation in the study through an opt-out method.

Nutritional status

We assessed BMI as an indicator of nutritional status at hospital discharge. Nurses conducted weight assessments before breakfast at discharge, and height measurements were taken during admission. BMI was calculated as body weight (kg) divided by the square of height (m). In a previous study of heart failure patients in Japan, it was reported that patients with a BMI of less than 20.3 kg/m^2 had a higher mortality rate [7]. Therefore, we defined the BMI cut-off value as less than 20.3 kg/m^2.

Exercise habits

We surveyed exercise habits one year after hospital discharge. Questionnaires were mailed to the patients' homes along with return envelopes addressed to our hospital. The definition of exercise habits used in prognostic studies of patients with atrial fibrillation was adopted and modified [8]. Specifically, we inquired: (1) the frequency of engaging in moderate exercise in an average week and (2) the total duration of exercise typically performed per day. We defined exercise habits as engaging in at least 30 minutes of moderate exercise once a week.

Readmission

We recorded all-cause readmissions from the medical records. Additionally, along with questionnaires regarding the investigation of exercise habits, we also collected information: (1) the current vital status of the patient and (2) any admissions or non-scheduled hospitalizations within one year of discharge, including the reasons for these admissions. To ensure accurate information, we made phone calls to the patients' homes if confirmation could not be obtained through the questionnaires. Finally, we classified readmissions into the following categories: (1) heart failure, (2) cardiovascular, and (3) others.

Other variables

We extracted several variables from the medical records at hospital discharge, including age, sex, cognitive impairment, medical history, smoking history, New York Heart Association (NYHA) classification, left ventricular ejection fraction (LVEF), geriatric nutritional risk index (GNRI) [9], blood biochemical data, activities of daily living (ADL), and the Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC) risk score [10]. Cognitive impairment was assessed using the Kihon Checklist-Cognitive Function (KCL-CF), a measure that predicts a Mini-Mental State Examination score of less than 23 [11]. The KCL-CF comprises three yes/no questions: (1) "Do your family or friends point out your memory loss (e.g., 'You ask the same question over and over again')?"; (2) "Do you make a call by looking up phone numbers?"; and (3) "Do you find yourself not knowing today's date?" Based on responses to these questions, each respondent received a KCL-CF score ranging from 0 to 3. Cognitive impairment was defined as a KCL-CF score of 1 or higher, according to a previous study [12]. ADL was assessed using the Barthel Index (BI) at hospital discharge. The MAGGIC risk score comprises the patients' age, sex, LVEF, BMI, creatinine level, NYHA class, smoking status, complications (diabetes and chronic obstructive pulmonary disease), history of heart failure, and medication use (angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, and beta-blockers). Moreover, we investigated physiotherapy interventions during the year following hospital discharge in the following modalities: (1) outpatient, (2) home visit, and (3) day care service.

Sample size calculation

It has been reported that BMI affects prognosis [5,7]. Therefore, the effect size for BMI was set at a moderate level of 0.30. The alpha level and power were set at 0.05 and 0.80, respectively, resulting in a total sample size of 88 cases. These parameters were used for sample size calculation in G*Power ver. 3.1.9.7 (Heinrich-Heine-Universität Düsseldorf).

Statistical analysis

Patients were classified into the following four groups according to BMI cut-off value and exercise habits at the time of discharge: Lower BMI/non-exerciser, lower BMI/exerciser, non-lower BMI/non-exerciser, and non-lower BMI/exerciser. Data are expressed as the mean and standard deviation for normally distributed variables and as the median with quartiles for non-normally distributed data. Categorical data are presented as numbers and percentages. Baseline patient characteristics according to BMI and exercise habits were compared using a one-way analysis of variance or the Kruskal– Wallis test for continuous variables and chi-square tests for categorical variables, as appropriate.

To the all-cause readmission rates, we calculated the 100 person-years for each patient from hospital discharge to the event occurrence or the follow-up date. We described Kaplan-Meier survival curves, and event rates were compared using log-

rank tests to assess the significance of all-cause readmission among the four groups. Cox regression analysis was performed to determine the impact of BMI and exercise habits on all-cause readmission. We first examined the impact of BMI<20.3 kg/m^2 and exercise habits alone on all-cause readmission. Subsequently, we analyzed the impact of the four groups classified by BMI<20.3 kg/m^2 and exercise habits on all-cause readmission. Confounding factors included age>80, male sex, cognitive impairment, log N-terminal pro-brain natriuretic peptide (NT-pro BNP), NYHA class, LVEF, and BI score<100. Statistical analyses were conducted using SPSS software version 28.0, with a significance level set at <5%.

RESULTS

Fig. 1 shows the flowchart of the study patients. A total of 174 patients were admitted to our hospital between August 2020 and February 2022. We excluded 7 patients due to death during hospitalization, 6 patients due to missing data, 31 patients due to death within 1 year from discharge, and 33 patients due to questionnaire non-response. The causes of death for the 31 patients who died within 1 year from discharge were as follows: 17 patients died of heart failure, 10 patients died of other causes, and 4 patients died of unknown causes. Of these 31 patients, a total of 9 were readmitted to the hospital. Finally, we analyzed 97 patients in this study.

The median age of the patients was 81 years (75–87 years), with 57.7% being male. The median BMI was 20.8 kg/m^2 (18.0–22.7 kg/m^2). Fifty-two patients (53.6%) reported having exercise habits during the year following hospital discharge. Patients were categorized as lower BMI/non-exerciser (n=24, 24.7%), lower BMI/exerciser (n=22, 22.7%), non-lower BMI/non-exerciser (n=21, 21.6%), and non-lower BMI/exerciser (n=30, 30.9%).

Table 1 presents the characteristics of the patients. The lower BMI/non-exerciser group had significantly higher age and MAGGIC risk scores, as well as significantly lower BMI, GNRI, and BI at discharge compared to the non-lower BMI/exerciser

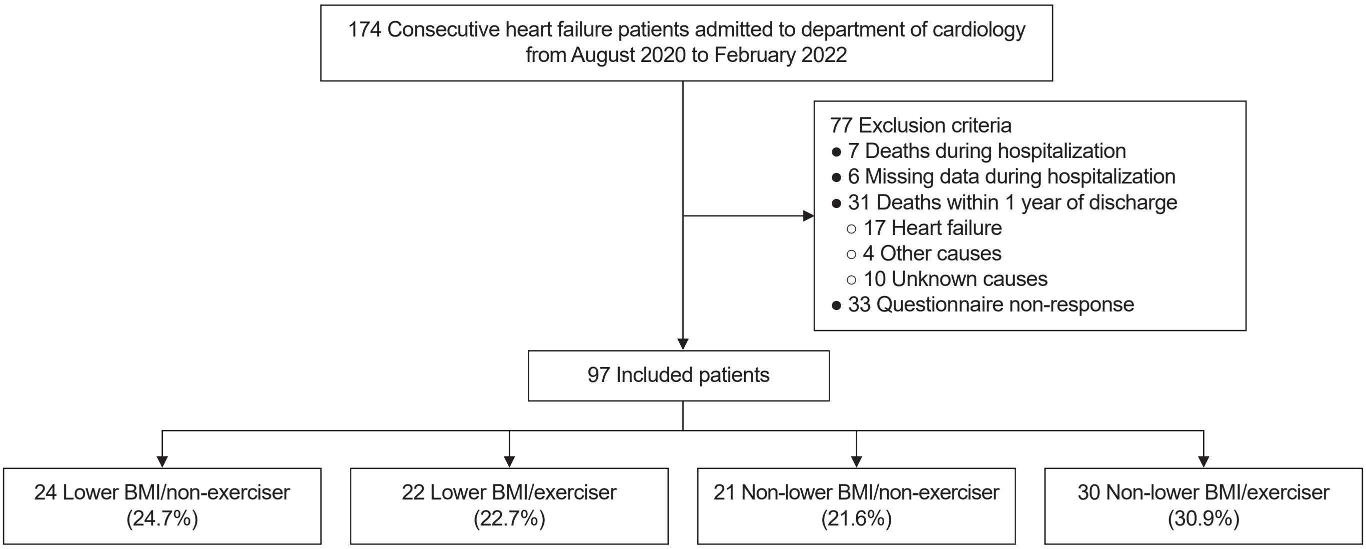

Fig. 1. Flowchart of the study. BMI, body mass index.

group. Additionally, a higher proportion of patients in the lower BMI/exerciser group were classified as NYHA class III and IV compared to the non-lower BMI/exerciser group. However, cognitive impairment, physiotherapy interventions during the year following hospital discharge, and living alone did not differ significantly among the four groups.

During the 1-year follow-up after hospital discharge, 46 patients (47.4%) experienced readmission (22 for heart failure, 9 for cardiovascular reasons, and 21 for other causes). All-cause readmissions occurred in 17 patients (70.8%) in the lower BMI/non-exerciser group, 12 patients (57.1%) in the non-lower BMI/non-exerciser group, 10 patients (33.3%) in the non-lower BMI/exerciser group, and 7 patients (31.8%) in the lower BMI/exerciser group. There were no significant differences in readmissions due to heart failure and cardiovascular reasons among the four groups.

Kaplan-Meier curves for all-cause readmission showed significant differences among the four groups (log-rank p=0.027; Fig. 2). The results of the cox proportional hazards analysis are presented in Table 2. In the multivariable model, being an exerciser or having a BMI<20.3 kg/m^2 alone did not independently impact prognosis after adjusting for age, sex, log NT-pro BNP, LVEF, NYHA class, and BI at discharge. However, the non-lower BMI/exerciser group had significantly lower readmission rates even after adjusting for confounding factors (non-lower BMI/exerciser vs. lower BMI/non-exerciser: hazard ratio, 0.26; 95% confidence interval, 0.08–0.83; p=0.022). Conversely, the non-lower BMI/non-exerciser group had no independent prognostic impact.

DISCUSSION

We examined the impact of the coexistence of BMI and exercise habits on readmission in older patients with heart failure. The main result of this study is that patients with both a non-lower BMI and regular exercise habits exhibited significantly lower readmission rates. This study represents the first to find that the coexistence of BMI and exercise habits leads to lower readmission rates in older patients with heart failure.

Patients with both a non-lower BMI and regular exercise habits exhibited significantly lower readmission rates. In Japanese patients, it has also been reported that a higher BMI is associated with lower 30-day readmission rates in patients with Japanese heart failure [13]. Additionally, non-lower BMI has been associated with significantly lower all-cause mortality and heart failure readmission rates in Japanese patients [5,7]. The indicators related to the exercise habits of heart failure patients have been shown to influence readmission rates. Reduced daily step count is associated with decreased exercise capacity [14], and exercise capacity itself is a prognostic factor in patients with heart failure [15]. Patients with no exercise habits likely had lower exercise capacity, which may have resulted in a higher rate of readmission. However, it is reasonable to conclude that the combination of a non-lower BMI and exercise habits

Table 1. Baseline characteristics at discharge

Variable	Lower BMI/non-exerciser N=24 (24.7%)	Lower BMI/exerciser N=22 (22.7%)	Non-lower BMI/non-exerciser N=21 (21.6%)	Non-lower BMI/exerciser N=30 (30.9%)	p-value
Age (yr)	84.5±5.7[b)]	79.8±7.1	82.0±7.7	77.1±8.4	0.004
Male (%)	10 (41.7)	17 (77.3)	13 (61.9)	16 (53.3)	0.095
Living alone (%)	9 (37.5)	8 (36.4)	1 (4.8)	8 (26.7)	0.054
BMI (kg/m^2)	18.2 (15.9–19.1)[b),d)]	17.8 (16.6–19.4)[b),d)]	22.6 (22.3–25.9)	22.5 (21.9–24.7)	<0.001
Cognitive impairment (%)	13 (54.2)	12 (54.5)	16 (76.2)	17 (56.7)	0.386
GNRI	80.1 (62.0–90.7)[a),c)]	84.0 (75.8–92.0)[a),c)]	98.8 (85.9–102.8)	95.1 (80.0–102.2)	<0.001
Etiology (%)					
Ischemic	3 (12.5)	2 (9.1)	8 (38.1)	10 (33.3)	0.042
Cardiomyopathy	0 (0)	5 (22.7)	2 (9.5)	2 (6.7)	0.059
Valvular heart disease	15 (62.5)	12 (54.5)	6 (28.6)	15 (50.0)	0.137
Comorbidities (%)					
Prior history of heart failure	9 (37.5)	13 (59.1)	7 (33.3)	11 (36.7)	0.280
Diabetes mellitus	6 (25.0)	5 (22.7)	10 (47.6)	11 (36.7)	0.266
Hypertension	17 (70.8)	10 (45.5)	15 (71.4)	25 (83.3)	0.034
Dyslipidaemia	3 (12.5)	2 (9.1)	6 (28.6)	7 (23.3)	0.292
Chronic kidney disease	5 (20.8)	6 (27.3)	5 (23.8)	7 (23.3)	0.966
COPD	3 (12.5)	1 (4.5)	2 (9.5)	1 (3.3)	0.556
History of cancer	7 (29.2)	7 (31.8)	4 (19.0)	6 (20.0)	0.666
Peripheral vascular disease	0 (0)	0 (0)	1 (4.8)	1 (3.3)	0.579
Smoking	4 (16.7)	6 (27.3)	9 (42.9)	7 (23.3)	0.240
NYHA class (%)					0.042
I	1 (4.2)	3 (13.6)	3 (14.3)	1 (3.3)	
II	4 (16.7)	8 (36.4)	3 (14.3)	16 (53.3)	
III	18 (75.0)	11 (50.0)	15 (71.4)	13 (43.3)	
IV	1 (4.2)	0 (0)	0 (0)	0 (0)	
NYHA class>III (%)	19 (79.2)	11 (50.0)	15 (71.4)	13 (43.3)	0.027
LVEF (%)	63.0 (50.6–67.8)[e)]	46.0 (32.8–60.2)	58.0 (35.9–63.5)	51.1 (39.8–61.5)	0.015
Laboratory data					
Creatinine (mg/dL)	1.09 (0.79–1.53)	1.00 (0.87–1.35)	1.17 (0.91–1.55)	1.11 (0.79–1.45)	0.748
BUN (mg/dL)	27.5 (22.1–40.3)	28.4 (22.8–42.1)	22.6 (17.9–29.0)	22.7 (15.0–37.4)	0.266
Albumin (g/dL)	3.4 (2.9–4.0)	3.6 (3.1–4.0)	3.6 (3.3–3.9)	3.6 (3.0–3.8)	0.628
Hemoglobin (g/dL)	11.5±1.8	11.6±1.9	11.8±2.0	11.8±3.1	0.944
NT-pro BNP (pg/mL)	4,482 (2,516–12,961)	3,728 (1,722–5,486)	3,635 (1,568–6,150)	5,170 (1,840–11,000)	0.771
Medication (%)					
ACE-I/ARB	13 (54.2)	13 (59.1)	15 (71.4)	22 (73.3)	0.412
ARNI	2 (8.3)	2 (9.1)	4 (19.0)	3 (10.0)	0.655
SGLT2	5 (20.8)	2 (9.1)	7 (33.3)	12 (40.0)	0.070
Beta blocker	12 (50.0)	17 (77.3)	19 (90.5)	21 (70.0)	0.024
Loop diuretic	19 (79.2)	20 (90.9)	17 (81.0)	27 (90.0)	0.543
MAGGIC risk score	33 (30–35)[b)]	28 (26–32)	29 (27–32)	26 (22–29)	<0.001
Barthel Index score	90 (80–100)[a)]	100 (90–100)	100 (90–100)	100 (90–100)	0.024
Barthel Index score<100	16 (66.7)	7 (31.8)	8 (38.1)	8 (26.7)	0.026
Exercise habits (exerciser)	0 (0)	22 (100)	0 (0)	30 (100)	<0.001
Readmission (%)					
All-cause	17 (70.8)	7 (31.8)	12 (57.1)	10 (33.3)	0.014
Heart failure	6 (25.0)	5 (22.7)	5 (23.8)	6 (20.0)	0.969
Cardiovascular	5 (20.8)	0 (0)	2 (9.5)	2 (6.7)	0.098
Others	7 (29.2)	3 (13.6)	5 (23.8)	6 (20.0)	0.639

BMI, body mass index; GNRI, geriatric nutritional index; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; BUN, blood urea nitrogen; NT-pro BNP, N-terminal pro-brain natriuretic peptide; ACE-I, angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor blocker; ARNI, angiotensin receptor neprilysin inhibitors; SGLT2, sodium-glucose co-transporter-2; MAGGIC, Meta-Analysis Global Group in Chronic Heart Failure.

[a)]p<0.05 vs. non-lower BMI/exerciser; [b)]p<0.01 vs. non-lower BMI/exerciser; [c)]p<0.05 vs. non-lower BMI/non-exerciser; [d)]p<0.01 vs. non-lower BMI/non-exerciser; [e)]p<0.05 vs. lower BMI/exerciser.

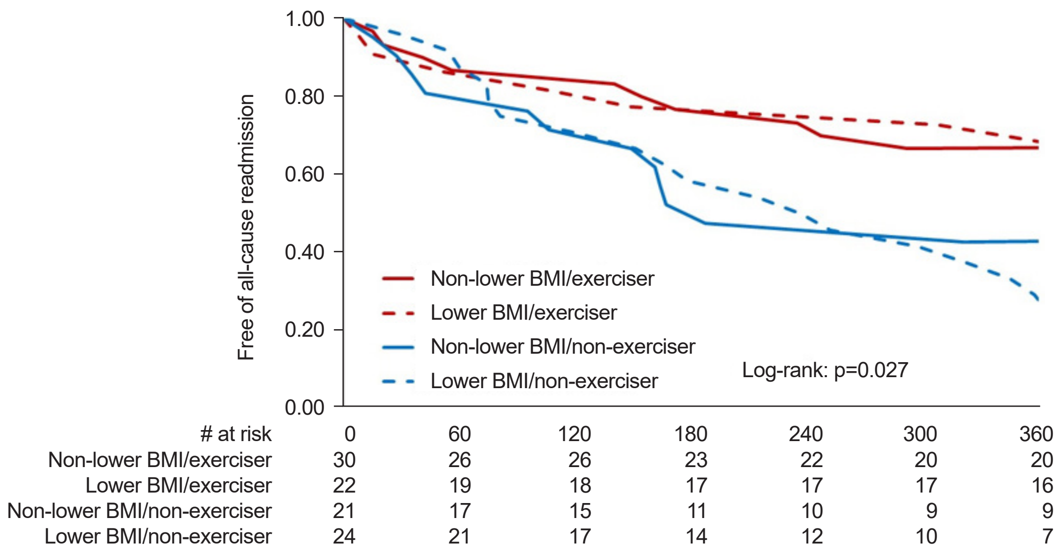

Fig. 2. Kaplan-Meier graph describing 1-year readmission for the 4 groups of patients based on body mass index (BMI) and exercise habits.

Table 2. Unadjusted and adjusted cox regression analysis for 1-year readmission

	Univariable model			Multivariable model			Multivariable model		
	HR	95% CI	p-value	HR	95% CI	p-value	HR	95% CI	p-value
Age>80 yr	1.32	0.72–2.43	0.368	0.65	0.23–1.82	0.410	0.65	0.23–1.86	0.424
Male sex	0.57	0.32–1.01	0.056	0.52	0.25–1.09	0.084	0.52	0.24–1.16	0.110
BMI<20.3 kg/m^2	1.21	0.68–2.17	0.512	1.76	0.81–3.81	0.155	-	-	-
Cognitive impairment	0.99	0.55–1.79	0.980	1.26	0.53–3.01	0.605	1.26	0.53–3.01	0.602
Log NT-pro BNP	1.02	0.78–1.34	0.897	1.09	0.75–1.58	0.670	1.08	0.75–1.58	0.673
NYHA class (per +1 class)	1.24	0.78–1.95	0.366	0.63	0.31–1.27	0.194	0.63	0.31–1.27	0.197
LVEF (per +1%)	1.00	0.98–1.02	0.822	1.01	0.98–1.04	0.571	1.01	0.98–1.04	0.599
Barthel Index score<100	0.92	0.49–1.75	0.803	0.80	0.32–1.99	0.634	0.81	0.32–2.04	0.652
Exerciser	0.41	0.23–0.75	0.004	0.46	0.19–1.07	0.071	-	-	-
Lower BMI/non-exerciser		1 (reference)		-	-	-		1 (reference)	
Lower BMI/exerciser	0.37	0.15–0.89	0.027	-	-	-	0.44	0.14–1.37	0.438
Non-lower BMI/non-exerciser	0.83	0.40–1.75	0.628	-	-	-	0.55	0.19–1.61	0.274
Non-lower BMI/exerciser	0.39	0.18–0.86	0.019	-	-	-	0.26	0.08–0.83	0.022

HR, hazard ratio; CI, confidence interval; NT-pro BNP, N-terminal pro-brain natriuretic peptide; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; BMI, body mass index.

significantly reduced readmission rates in elderly heart failure patients.

Although the pathophysiological explanation for the poor prognosis of heart failure patients with lower BMI remains speculative, several mechanisms have been proposed to explain this outcome. First, heart failure is a well-known catabolic condition [16], and patients with lower BMI may have reduced metabolic reserves to withstand the increased catabolic stress associated with heart failure. Second, inflammatory cytokines may be involved. Elevated levels of tumor necrosis factor-α (TNF-α), a marker of inflammation, are associated with poor prognosis [17]. TNF-α has also been reported to act directly on the brain to decrease appetite [18]. Thus, increased inflammatory cytokines may contribute to BMI reduction and poor prognosis.

Despite having a non-lower BMI, a lack of exercise habits does not lead to a decrease in readmission rates. Studies have indicated that establishing regular exercise routines and increasing physical activity can effectively reduce cardiovascular mortality and readmission among individuals with heart failure [6].

Additionally, limited life space and decreased physical activity have been identified as risk factors for readmission in patients with congestive heart failure or chronic obstructive pulmonary disease [19]. The cultivation of exercise habits may also correlate with adherence to disease management protocols. Previous research has shown that greater disease knowledge is linked to higher levels of physical activity in patients with heart failure [20]. Conversely, insufficient disease knowledge has been associated with poor compliance with fluid restriction and weighing guidelines [21]. Noncompliance with prescribed medications has also been recognized as a risk factor for readmission in patients with heart failure [22]. Consequently, the absence of exercise habits may be intricately linked to factors such as disease management adherence, and these multifaceted considerations may contribute to the challenge of mitigating readmission rates, even in individuals with a non-lower BMI.

Study limitations

We found that both a non-lower BMI and regular exercise habits were associated with a significantly lower readmission rate. However, our study had several limitations. First, this was a single-center study, and future multicenter studies are needed to generalize our results. Second, we did not investigate the specific causes of the identified readmission rates. In the future, it is essential to identify readmission rates specifically attributable to heart failure. Third, because exercise habits were assessed by questionnaire, we did not obtain detailed information on physical activity behaviors, such as daily step counts, sedentary behavior, and other physical activity levels. Furthermore, the questionnaire has limitations in accurately measuring exercise. In future studies, physical activity should be objectively assessed using a three-dimensional accelerometer. Fourth, 31 patients who died within a year of discharge were excluded because their exercise habits could not be evaluated. However, 9 of these patients were readmitted within that year, which may have influenced the results. Therefore, regular post-discharge assessment of exercise habits may be necessary in future studies. Finally, our sample size was small, which may have resulted in limited statistical power. Therefore, the study should be reanalyzed with a larger number of patients.

Conclusions

We found that the coexistence of non-lower BMI and exercise habits during the 1-year may reduce readmission in older patients with heart failure. Both evaluating BMI and encouraging and monitoring continued physical activity after discharge are needed in older patients with heart failure.

CONFLICTS OF INTEREST

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

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None.

AUTHOR CONTRIBUTION

Conceptualization: Ozawa T, Sato R. Methodology: Ozawa T, Yuge M. Formal analysis: Ozawa T. Investigation: Ozawa T, Sato K, Izuoka Y. Project administration: Ozawa T, Yuge M. Visualization: Ozawa T, Inoue T, Naruke T. Supervision: Naruke T, Sato R, Shimoda N, Yuge M. Writing – original draft: Ozawa T. Writing – review and editing: Inoue T, Naruke T, Shimoda N, Yuge M. Approval of final manuscript: all authors.

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