



## Case Report

## Comprehensive cardiac rehabilitation utilized to support patients with heart failure for balancing treatment and work: A case report



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## ABSTRACT

A 47-year-old woman with exertional dyspnea was admitted to our hospital. Echocardiography revealed congestive heart failure (HF), with reduced left ventricular ejection fraction (13 %) and elevated brain natriuretic peptide levels (877 pg/mL). The patient underwent medical therapy and comprehensive cardiac rehabilitation (CR). At discharge, the oxygen uptake at anaerobic threshold (AT) was 13.1 mL/kg/min. Outpatient CR consisted of exercise therapy, patient education, and home activity intensity instructions with pulse rate (PR) management using a wearable device. We instructed that activity intensity at home should not exceed the PR at AT. Two months after discharge, the patient's condition was stable, and she was compliant with activity intensity restrictions; therefore, she was allowed to return to work twice a week for 5 h of light work weekly, which was gradually increased. We continued to monitor the PR with wearable devices to ensure compliance with work intensity. Five months after discharge, she achieved a return to work four times a week for 8 h without exacerbation of HF symptoms. The workplace was receptive to the suggestions of the CR team regarding workplace conditions, safe working hours, and frequency, and the patient successfully returned to work, achieving a balance between treatment and work.

**Learning objective:** The use of comprehensive cardiac rehabilitation is recommended for the return to work by patients with heart failure. However, specific measures to manage activity intensity for return to work have not been considered fully. The strategy that we adopted involved a combination of comprehensive cardiac rehabilitation and the use of wearable devices for guided work intensity management, allowing for a balance between treatment and work responsibilities.

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## Introduction

The return-to-work rate for patients with heart failure (HF) was reported to be 57.5 % at 6 months post-onset, accompanied by 30 % detachment from employment at 6 months post-return-to-work [1]. Self-assessed occupational prognosis is associated with returning to work [2].

Outpatient cardiac rehabilitation (CR) increases return-to-work rates [3], and we decided to promote vocational rehabilitation while utilizing outpatient CR. Although overload is an exacerbating factor of HF [4], a balance has been established between the need to increase physical activity and improve exercise capacity. Therefore, we focused on wearable devices for activity intensity management. Wearable devices are useful

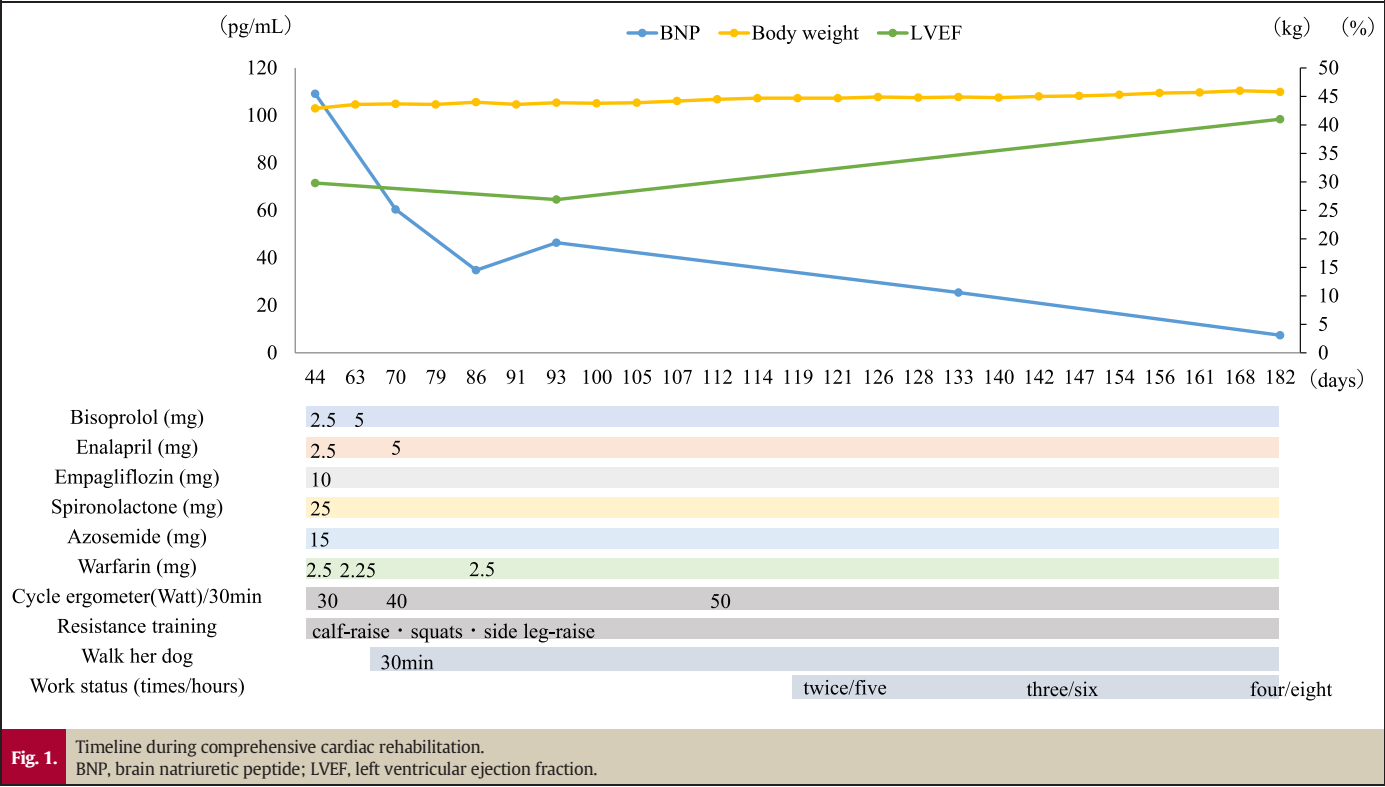
for patient monitoring, and as Apple Watch® (Apple Inc., Cupertino, CA, USA) is known to provide generally accurate pulse rate (PR) measurements [5], we used the Apple Watch® to monitor the volume and intensity of the activity during exercise.

Here, we describe an activity intensity guide using a wearable device, which suggests that the patient could comply with the intensity of exercise prescribed in the CR and engage in activities within the recommended intensity range while working.

## Case report

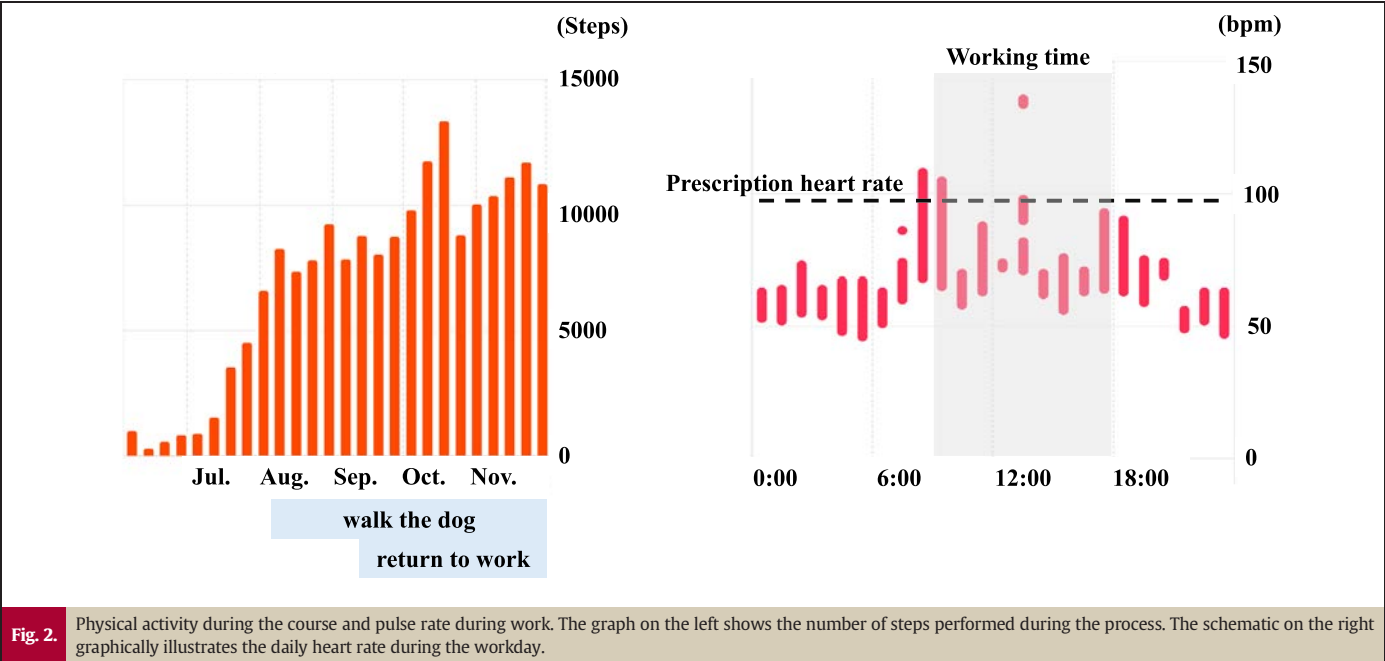
The patient was a 47-year-old woman who was a part-time employee of a supermarket and a dog owner. She became aware of cough and fatigue on exertion at the beginning of June 2023 and gained 7 kg over 2 weeks. Radiographic findings revealed a cardiothoracic ratio (CTR) of 65 % with vascular congestion. Laboratory tests revealed an

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elevated brain natriuretic peptide (BNP) level of 877.4 pg/mL, and echocardiography revealed a severely reduced left ventricular ejection fraction (LVEF) of 13.1 %. She was admitted to hospital with a diagnosis of HF. On admission, her height, weight, and body mass index (BMI) were 153.6 cm, 55.4 kg, and 23.4 kg/m<sup>2</sup>, respectively. Vital signs included blood pressure (BP), PR, respiratory rate, and percutaneous oxygen saturation of 150/114 mmHg, 140 beats/min, 40 breaths/min, and 97 % (2 L of oxygen), respectively. Cardiac auscultation detected S3 and S4 heart sounds, and physical examination revealed leg edema.

The patient was started on noninvasive positive pressure ventilation, diuretics, and vasodilators, and her hemodynamics stabilized within 2 days. At that time, her weight, BMI, BP, and PR were 45.2 kg, 19.2 kg/m<sup>2</sup>, 100/86 mmHg, and 113 beats/min, respectively, although S3 heart sounds and leg edema persisted. She was treated with cardioprotective drugs, and no further episodes of HF exacerbation occurred. She underwent graded early mobilization and started aerobic exercise using a bicycle ergometer on day 12. Coronary angiography was intact and myocardial biopsy revealed no specific findings, leading to a diagnosis of dilated cardiomyopathy by exclusion. She was discharged with a CTR of 51 % and a BNP level of 109.1 pg/mL and LVEF improved to 29.8 % by day 44. Outpatient CR was initiated at our hospital on day 63. The progress of the CR is shown in Fig. 1.



At discharge, the patient hoped to walk her dog and return to work. At that time, the peak oxygen uptake ( $\text{VO}_2$ ) was 19.7 mL/kg/min and  $\text{VO}_2$  at anaerobic threshold (AT) was 13.1 mL/kg/min, indicating an exercise capacity suitable for engaging in light labor at work. The first step was to monitor worsening HF symptoms in daily life, followed by gradual reintegration of activities, such as walking the dog and resuming work. Outpatient CR was performed 1–2 times per week at the patient's convenience. Exercise therapy consisted of aerobic exercise on a bicycle ergometer for 30 min at a heart rate corresponding to the AT (94 bpm) and resistance training with three sets of calf raises, squats, and side leg raises at a frequency of 13 on the Borg scale. The patient was instructed to use a wearable device (Apple Watch®) to assess whether the PR during activity complied with PR at AT and steps during home exercise (Fig. 2). Disease management was conducted by instructing the patient to record vital signs, weight, symptoms, medication status, and step count in a designated notebook. By day 70, BNP improved to 60.4 pg/mL, allowing the patient to initiate a 30-min walk with her dog. Instructions were for the intensity of dog walking not to exceed the PR of AT (94 bpm), and the number of steps to be maintained at 8000 steps. In fact, the number of steps complied with approximately 8000 steps, and no excess PR was observed. As there was no deterioration in HF symptoms, the physician permitted the patient to return to work twice a week for 5 h from day 119. Her job consisted of packing and cutting meat [2–3 Metabolic equivalents (Mets)], transporting meat, and taking inventory (approximately 4 Mets), and working in a cold environment. Although the HF status was stable, the EF remained depressed, and we continued to employ a PR of AT for activity intensity, taking into account the risk of HF exacerbation. We provided specific instructions to her supervisor to ensure that she avoided heavy lifting and exposure to cold environments and instructed her to continue using the wearable device to comply with PR at AT during work.

The evaluation of PR trend during work using a wearable device demonstrated compliance with the prescribed PR with activity increasing to a reinstatement of 10,000–12,000 steps (Fig. 2). After returning to work, the HR trend during exercise load was periodically checked by outpatient CR; however, no increase in HR was observed at the same load. Therefore, as HF status did not worsen after returning to work, the number of hours and frequency of work increased every month up to four times a week for 8 h. After 182 days, the CTR, BNP, and LVEF improved to 44 %, 7.4 pg/mL, and 41 %, respectively. In addition, the peak  $\text{VO}_2$  and  $\text{VO}_2$  at AT improved to 22.9 and 16.2 mL/kg/min (+3.2 mL/kg/min), respectively, after 26 sessions of outpatient CR (Table 1).

**Table 1**  
Hemodynamic results of symptom-limited cardiopulmonary exercise test and muscle strength.

Elapsed time	44 days	182 days
BW (kg)	43.6	45.7
Peak RER	1.51	1.34
Peak $\text{VO}_2$ (mL/min)	860	1401
Peak $\text{VO}_2$ /BW (mL/kg/min)	19.7	22.9
%predicted peak $\text{VO}_2$ (%)	84	97
AT $\text{VO}_2$ (mL/min)	640	741
AT $\text{VO}_2$ /BW (mL/kg/min)	13.1	16.2
%predicted AT $\text{VO}_2$ (%)	83	102
VE vs. $\text{VCO}_2$ slope	28.8	29
$\Delta\text{VO}_2$ /WR	8.1	9.2
Peak $\text{VO}_2$ /HR (mL/beat)	6.3	6.8
Rest HR (beats/min)	66	74
Peak HR (beats/min)	137	153
Borg scale (dyspnea/leg fatigue)	17/19	15/19
Grip (kg)	16.5	20.4
Knee extensor muscle strength (kg)	23.4	25.6

The ramp protocol was performed in 10-Watt increments in both the pre- and post-tests. BW, body weight; RER, respiratory gas exchange ratio;  $\text{VO}_2$ , oxygen uptake; AT, anaerobic threshold; VE, minute ventilation;  $\text{VCO}_2$ , carbon dioxide output; WR, work rate; HR, heart rate.

## Discussion

This case shows that the patient was able to return to work without exacerbation of HF by using a wearable device to manage safe exercise intensity calculated by cardiopulmonary exercise testing during home exercise therapy and at work based on the PR. According to a statement by the American Heart Association [6], the patient was classified into Class C because the LVEF was less than 30 %, and exercise tolerance was less than 6 Mets. Patients in Class C have a moderate to high risk of HF exacerbation during exercise, and activity should be individualized, with medical and electrocardiogram monitoring until safety is established. As the patient wished to walk her dog and return to work, home-based exercise therapy and dog walking were permitted with monitoring of the PR using an Apple Watch® to ensure appropriate intensity. BNP was checked periodically, and no element of exacerbation was observed. The safety of home exercise at the prescribed intensity was subsequently confirmed to be adequate, and the patient was capable of self-management; thus, we considered her reinstatement.

Taking into account the workload of the patient, light exertion is acceptable, but moderate exertion is conditionally acceptable, and it is desirable to monitor the patient's condition during work. Therefore, we examined the acceptable work at the time of return to work and decided to check the patient's PR during work using a wearable device. In fact, the patient was able to comply with work intensity, which resulted in the prevention of exacerbation of HF associated with work.

She recovered from HF with reduced ejection fraction to HF with mid-range ejection fraction following guideline-directed medical therapy. Patients with HF with reduced ejection fraction have a better prognosis than HF with mid-range ejection fraction [7]. In the cardiopulmonary exercise test, peak  $\text{VO}_2$ /HR improved over time. Therefore, this improvement in cardiac function may have improved the exercise capacity. Exercise capacity improved with CR. The patient also had improved lower extremity muscle strength, and the peripheral effects associated with exercise therapy also contributed to improved exercise capacity, which may have contributed to a reduction in work-related overload.

In this case, the patient implemented a carefully structured, phased return-to-work plan. The strategy involved a combination of comprehensive CR and the use of wearable devices for guided work intensity management, allowing for a harmonious balance between treatment and work responsibilities.

## Consent statement

Written informed consent was obtained from the patient.

## Declaration of competing interest

The authors declare that there is no conflict of interest.

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