Evidence-based effects of cardiac rehabilitation and dietary therapy

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Abstract

The cardiac pumps blood throughout the body without rest. When the cardiac is diseased, blood flow is reduced and sometimes blood clots may cause blood vessels to become blocked, leading to death. Cardiac disease is progressive and difficult to cure. Cardiac rehabilitation includes the following comprehensive methods: education for the patient and family, exercise therapy, counseling, nutrition and dietary advice, medication guidance, living guidance, control for stress, return to work training, etc. Those cover a wide range of fields and it is difficult for patients to carry out those methods independently. Therefore, there is a demand for simple cardiac rehabilitation. Tohoku University developed a cardiac rehabilitation method using three types of exercise therapies, and qualitative effects were observed about five years ago. However, a quantitative evaluation is still not fully understood. It is commonly known that losing weight reduces the workload of the cardiac, however, it is unclear how much improvement will be achieved. Cardiac rehabilitation and dietary therapy were carried out on a patient with chronic cardiac failure and complications of atrial fibrillation, and hypertension in this study, and the progress of the subject's condition was examined. The subject underwent Tohoku University-style cardiac rehabilitation three times a day in this experiment. Namely, weight, blood pressure (systolic and diastolic blood pressures), pulse rate, irregular pulse waves (arrhythmia), etc. were measured at waking and bedtime. The attending doctor regularly checked the subject's cardiac failure marker levels and used an electrocardiogram to check the frequency of arrhythmias and a comprehensive judgment was carried out.

Key words

cardiac rehabilitation, exercise therapy, diet therapy, systolic blood pressure, pulse rate

1. Introduction

Cardiac rehabilitation is a comprehensive program designed to help people with cardiac disease regain their strength, prevent recurrence and improve their quality of life. It is provided by a multidisciplinary team including a doctor, nurse, physiotherapist, nutritionist, pharmacist and clinical psychologist etc. The objective is to review the following:

(1) Prevent the progression and recurrence of cardiac disease, (2) improve athletic ability and physical strength, (3) review the patient's lifestyle habits (diet, exercise, smoking cessation, etc.) and reduce psychological stress such as anxiety and depression, (4) support for reintegration into society (work and family life). The diseases covered in item (4) include myocardial infarction, angina pectoris, cardiac failure, post-cardiac surgery (by-pass surgery, valve replacement surgery, etc.), post-trans catheter intervention (PCI, TAVI, etc.), and cardiomyopathy. The main items are exercise therapy, lifestyle guidance, psychosocial support, and medical management. The treatment is usually given once or twice a week as an outpatient for about three months. The following effects have been confirmed: reduced re-hospitalization rate, reduced mortality rate, and improved physical fitness and quality of life. It is demonstrated that cardiac rehabilitation and dietary therapy are effective against cardiac disease through short-term measurements in this study (Balady et al., 2007; Kouzuki, 1994; Piepoli et al., 2016; The Japanese Association of Cardiac Rehabilitation, 2021a; 2021b).

2. Cardiac rehabilitation methods

Cardiac rehabilitation methods used in this study adopted the following three rehabilitation methods developed at Tohoku University Hospital in 1994 (Takahashi, 2020) and the subject (male, 73 years old) performed those methods as a routine three times each day: in the morning, afternoon, and evening.

2.1 Special typed walking (aerobic exercise)

This type is called '*ikiiki* walking' in Japanese. The subject looks straight ahead and keeps his gaze a little distance away in this type of walking, and clenches his fists lightly and swings arms back and forth. He stands with his chest out, knees straight, and back straight and lands on his heels and pushes off with the toes. Take as long as stride as possible and walk to avoid getting out of breath. Limit to 90 minutes a day. The walking goal is 30 minutes a day (about 3,000 steps).

2.2 Squat in a relaxed manner (muscle training)

To implement this squat process effectively: (i) stand with his hands on the hips and feet shoulder-width apart, shoulders relaxed and the feet shoulder-width apart. (ii) As he exhales slowly through the mouth, bend the knees slightly and lower the hips over the course of five seconds. Stand up

straight. (iii) Once he has lowered the hips, breathes in slowly through the nose and he returns to position (i) over the course of five seconds. The goal is to do it three times a day, in the morning, afternoon and evening (three sets in total). The steps (i) to (iii) are repeated 10 times as a set. Take breaths during exercise and never hold the breath. The height of the hips should be up to the knees, not too low. Do not let the knees go in front of the toes. Place the heels on the ground when squatting.

2.3 Relaxing and standing on one leg (balancing and bone strength)

(i) Place the right hand lightly on the back of a chair or on the handrail, and stand naturally with both eyes open. (ii) Lift the right foot about 5cm off the floor and hold the condition there for one minute. Breathing continues naturally. (iii) Place the left hand lightly on the back of a chair or on the handrail, and stand naturally with both eyes open. (iv) Lift the left foot about 5cm off the floor and hold the condition there for one minute. Breathing continues naturally. (v) The goal is to do this three times a day, in the morning, afternoon and evening (three sets in total). Perform steps (i)-(ii) once for the right leg, and steps (iii)-(iv) once for the left leg (total of 2 minutes) as one set.

3. Diet therapy

Food contents have a big impact on human cardiac, blood vessels and blood pressure. The following points were taken into consideration when consuming food in this study.

(1) Avoid greasy food (fried or stir-fried foods).
(2) Do not overeat (suppress appetite).
(3) Avoid processed meat products (sausages, bacon, etc.) .
(4) Avoid processed fish products (*kamaboko*, *chikuwa*, etc.).
(5) Eat soy foods (*tofu*, *natto*, fried *tofu*, soy milk, etc.).
(6) Avoid sweets, pastries, and snacks.
(7) Avoid pickles, *tsukudani*, and *furikake*.
(8) Do not eat *ramen* after drinking alcohol.
(9) Do not eat a late-night snack right before bedtime.
(10) Do not just eat rice balls, bread, or noodles for lunch. Always eat a side dish.
(11) Eat actively mushrooms, seaweed, and *konnyaku*.
(12) Chew food thoroughly (do not eat too quickly).
(13) Do not drink alcohol or juice every day. Take a day off from drinking.
(14) Do not eat while watching TV or using a smartphone.
(15) Do not drink *miso* soup or soup with every meal.
(16) Eat plenty of vegetables and fruits.
(17) Lightly season the food.
(18) Reduce the frequency of eating out. Once a week or less is appropriate.
(19) Always eat breakfast.

Capsaicin (found in spices such as chili peppers) has the effect of reducing aspiration. Eating slowly prevents blood sugar levels from rising and it prevents inflammation and illness caused by the aspiration. Eat all the leafy greens early in the meal. Vegetables contain dietary fiber, which stimulates the secretion of a hormone called GLP-1 in the intestines. The GLP-1 not only slows down stomach movement and promotes insulin secretion to lower blood sugar levels, but also acts on the central nervous system in the brain to suppress the appetite. Those reduce the rise in blood sugar levels after meals and reduce the strain on the heart.

4. Subject's initial symptoms

The subject A (male, 73 years old) was adopted in this study. His condition was hypertension and chronic tachycardia atrial fibrillation, and he was already in a state of cardiac failure. Tachycardia means a heart-rate of more than 100 beats per minute. Atrial fibrillation is a type of arrhythmia in which the atria spasm. When the condition becomes chronic, the atria are constantly spasming and the pulse becomes irregular. This is a progressive disease that becomes more common with age and is difficult to cure. This disease causes blood to stagnate in the lungs, liver, and other organs. And it leads to a variety of symptoms such as difficulty breathing, swelling, palpitations, and fatigue. This failure is a syndrome of weakened cardiac function caused by various underlying diseases. The most important problem with atrial fibrillation is that blood clots formed in the cardiac can travel and become blocked in peripheral blood vessels such as those in the brain (causing a stroke). This disease is more likely to occur with age.

The status of the subject's treatment was as follows:

- He was undergoing medication and dietary therapy for his hypertension.
- He was taking anticoagulants (Eliquis tablets) in consideration of the risk of thrombosis regarding a stroke. Taking anticoagulants increases the risk of bleeding.
- He was taking an antiarrhythmic drug (Bisoprolol Fumarate Tablets 5 mg) for atrial fibrillation. The antiarrhythmic drugs have limited effectiveness and he was no longer feeling any effect. Catheter ablation treatment is usually performed in such a case. However, his family doctor said there was a high chance of recurrence, so he should be prepared to live with atrial fibrillation for the rest of his life. His cardiac failure marker level was significantly higher than the standard values during a regular health check on January 23, 2024. The changes in cardiac failure marker values are shown in Table 1. There are two types of cardiac failure markers: BNP and NT-proBNP and the respective reference values are 18.4 pg/ml and 125 pg/ml.

Table 1: Changes in subject A's cardiac failure markers (BNP, NT-proBNP)

Date		(pg/ml)	Converted to NT-proBNP
2024/1/23	NT-proBNP :	817.0	
2024/5/18	NT-proBNP :	771.0	
2024/8/2	BNP :	137.7	(about 525 pg/ml)
2024/9/7	NT-proBNP :	820.0	
2024/11/9	NT-proBNP :	1158.0	
2025/1/7	NT-proBNP :	1138.0	
2025/1/10	BNP :	205.9	(about 927 pg/ml)
2025/4/5	NT-proBNP :	730.0	
2025/6/14	NT-proBNP :	871.0	

5. Medication

The medications he was taking are as follows:

(1) Eliquis tablets
[Action and Efficacy]: Prevent blood from clotting and blood clots.
(2) Bisoprolol fumarate tablets 5 mg
[Action and Efficacy]: Prevent angina attacks, lower blood pressure, regulates irregular pulse, help the cardiac function. (Note) dizziness may occur
(3) Lisinopril tablets 10mg
[Action and Efficacy]: Lower blood pressure, help cardiac function. (Note) dizziness may occur
(4) Tsumura goshajinkigan extract granules (107)
[Action and Efficacy]: Improve swelling and itching and blurred vision, relieve symptoms such as pain, numbness, and chills in the lower back and legs, improve symptoms such as difficulty urinating, frequent urination, and polyuria, compensating for the decline in bodily functions.
(5) Methycobal Tablets
[Action and Efficacy]: Relieve numbness.
(6) Febuxostat tablets 10 mg
[Action and Efficacy]: Inhibit uric acid synthesis.
(7) Naftopidil tablets 50 mg
[Action and Efficacy]: Improve symptoms associated with prostate enlargement.
(8) Rize tablets 5 mg
[Action and Efficacy]: Effective for deep sleep, relieve muscle stiffness, relieve anxiety and tension.
(9) Tsumura Asakoninmaru extract granules (126)
[Action and Efficacy]: Make stool (feces) easier.
(10) Promac D Tablets 5mg
[Action and Efficacy]: Protect the stomach lining.
(11) Amlodipine tablets
[Action and Efficacy]: Prevent angina attacks, lower blood pressure. (Note) his blood pressure started to drop three months after the start of this study. He stopped taking blood pressure lowering medication (11) at his doctor's discretion. He is not currently taking any of the (11) medication.

6. Experimental results

The experimental results are divided into seven categories.

(1) Subject's weight measurements and cardiovascular examination results from previous health checkups. The result is indicated in Table 2. His height is 172.7 cm. As can be seen from the table, he gradually developed hypertension and his weight-to-height ratio increased. The electrocardiogram in this table was still within normal limits. An abnormality was found in the electrocardiogram markers after four months later.
(2) The cardiac rehabilitation method was started around mid-February 2025. Data was collected from March 22, 2025. Body weight was measured twice a day, at waking and bedtime. Each value is the average of two measure-

Table 2: Weight measurements and cardiovascular examination results in previous health checkups

Examination date	Weight (kg)	Systolic	Diastolic	Electrocardiogram (findings)
		Blood pressure (mmHg)		
2018/8/20	73.5	123	81	within the normal
2019/8/19	72.0	128	81	within the normal
2020/9/23	73.0	137	82	within the normal
2021/9/22	73.0	144	86	within the normal
2023/9/21	71.5	145	91	within the normal

Table 3: Blood pressure, weight, pulse rate, number of steps, etc. for one week from Saturday March 22, 2025

Date	3/22 (Sat)	3/23 (Sun)	3/24 (Mon)	3/25 (Tue)	3/26 (Wed)	3/27 (Thu)	3/28 (Fri)
Body weight (at waking)			70.3	70.7	70.5	70.7	70.2
Body weight (bedtime)		71.2	71.5	71.0	71.3	71.0	71.1
Blood pressure (at waking)							
Systolic blood pressure	100.5	108.0	108.5	113.0	113.0	120.5	111.0
Diastolic blood pressure	74.0	77.5	77.5	91.0	84.0	82.0	85.0
High blood pressure determination	×	×	×	○	×	×	○
Pulse	71.0	71.5	77.0	82.5	84.5	76.0	73.0
Irregular pulse wave	○	○	×	○	○	○	○
Blood pressure (bedtime)							
Systolic blood pressure	112.0	105.5	114.0	101.5	98.5 (low)	87.0 (low)	101.5
Diastolic blood pressure	78.5	72.0	81.0	76.0	74.5	66.0	77.0
High blood pressure determination	×	×	×	×	×	×	×
Pulse	68.5	78.0	76.0	86.0	76.5	67.0	72.5
Irregular pulse wave	○	○	○	○	○	○	○
Cardiac rehabilitation carried out	○	○	○	○	○	○	○
Number of steps	5300	1600	6532	4550	6141	6862	6031
Stress(1-3)	1	1	2	3	2	2	2

Notes: High blood pressure determination = ○ High blood pressure, × Not. Irregular pulse wave = ○ Irregular pulse wave, × Not.

ments. Data was measured at waking before taking medication. Systolic blood pressure, diastolic blood pressure, and pulse rate were also measured twice, once at waking and once upon going to bed. Each value is the average of two measurements. The irregular pulse waves are considered arrhythmias in this paper. The number of steps was indicated just before bedtime, and the stress was measured as a self-reported value on the three-stages. For example, the values for blood pressure, weight, pulse, number of steps, etc. for one week from March 22 (Saturday) are shown in Table 3.

(3) Changes in body weight at waking and bedtime during the early period (April to May) are shown in Table 4 and 5. The blank spaces in Table 5 represent the days when the measurements could not be taken due to business trips, etc. Table 4 and 5 are graphed and shown in Figure 1 and 2. As can be seen from Figure 1 and 2, the weight at waking is lower than at bedtime. The basal metabolism reduces the weight when waking, and it increases when he goes to bed due to the dinner eaten. The weight was gradually decreased during the first half of the experiment due to dietary therapy. However, his weight temporarily increased from early to mid-May. The reason for this is thought to be that the subject gained weight because he ate different foods than usual when eating out or traveling. In addition, one possible reason why the reduction in blood pressure did not directly lead to weight loss is the influence of pharmacological treatment, apart from salt intake. This is because the medications being taken, bisoprolol fumarate tablets and lisinopril tablets,

Table 4: Weight changes (kg) at waking and bedtime from March 24 to May 2, 2025

	3/24	3/25	3/26	3/27	3/28	3/29	3/30	3/31	4/1	4/2	4/3	4/4	4/5	4/6
	70.3	70.7	70.5	70.7	70.2	70.6	70.3	70.1	70.2	70.2	70.0	69.8	70.1	70.2
	71.5	71.0	71.3	71.0	71.1	71.5	70.8	70.4	70.8	70.6	70.6	70.9	70.8	70.8
Month and day	4/7	4/8	4/9	4/10	4/11	4/12	4/13	4/14	4/15	4/16	4/17	4/18	4/19	4/20
At waking	70.4	70.4	70.1	70.1	70.0	69.6	69.3	69.5	69.1	69.4	69.7	69.6	69.3	69.1
Bedtime	70.9	70.8	70.7	70.6	70.3	70.2	70.5	70.1	70.1	70.6	70.5	69.8	69.5	70.3
	4/21	4/22	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30	5/1	5/2		
	69.8	69.2	69.3	69.6	69.1	68.7	69.1	69.1	68.9	69.4	69.4	69.5		
	69.8	70.0	70.0	69.9	69.4	69.6	69.6	70.0	70.1	70.4	70.1	69.9		

Table 5: Weight changes (kg) at waking and bedtime from May 3 to May 30, 2025

Month and day	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	5/16
At waking	69.2	69.0	69.2	69.5	69.4	69.6	69.4	69.1	69.7	69.5	68.8	69.0	68.8	69.0
Bedtime	69.4	69.7	70.2	70.0	70.2	69.9	69.6	70.3	70.3	69.3	69.4	69.7	69.9	69.7
	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30
	69.0	70.0	69.7	69.4	69.3	69.1	68.9	69.1			69.2	69.3	68.3	67.9
	70.6	70.6	69.9	69.7	69.7	69.7	69.5		69.3	69.5	69.7	69.6	68.6	

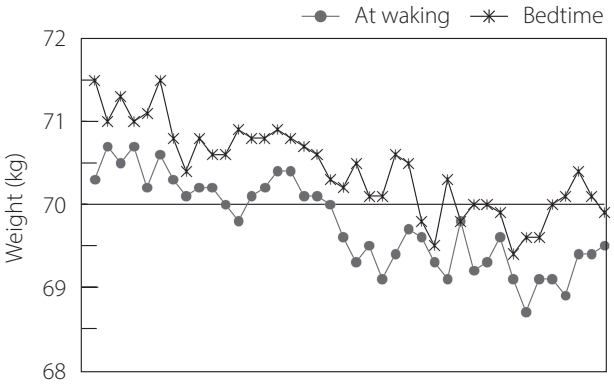

Figure1: Weight changes (kg) at waking and bedtime from March 24 to May 2, 2025

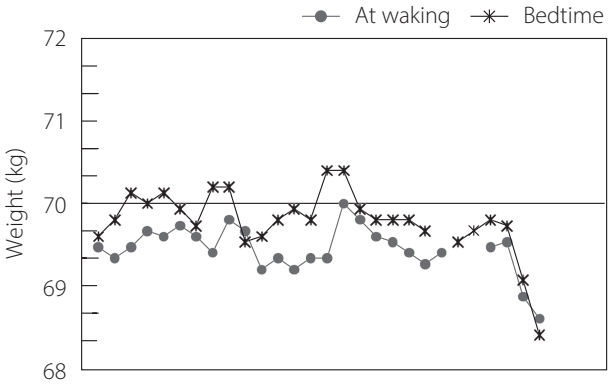

Figure 2: Weight changes (kg) at waking and bedtime from May 3 to May 30, 2025

have blood pressure-lowering effects.

(4) The weekly changes in weight and blood pressure at waking and bedtime during the early period of the experiment (April to May) are shown in Table 6. Table 6 is graphed and shown in Figure 3 and 4. Those figures show that both the systolic and diastolic blood pressures become higher at waking than bedtime. This phenomenon is called morning hypertension. It is considered a type of masked hypertension because it cannot be detected by blood pressure measurements in a doctor's office. A stroke, myocardial infarction, and sudden death occur more frequently in the morning, and one of the causes is thought to be early morning hypertension.

(5) It was thought that losing weight would lower the blood pressure and cardiac failure markers, but the measurement results revealed that this was not the case. Figure 3 and 4 show that blood pressure did not decrease, despite weight loss. The blood pressure rose dramatically in the week of May 30. The reason for this result is thought to be that he ate high-salt meals when eating out. Therefore, it is thought that his cardiac failure markers did not decrease on June 14th, even though his weight was approaching his standard weight (66 kg). Namely, it is unclear whether the cardiac rehabilitation, dietary therapy, and medication, which were the objectives of this study, were having any effect.

(6) The average pulse-rates at waking and bedtime on a weekly basis are explained in Table 7. The table is graphed in Figure 5. The average pulse rate for the elderly is 50 to 70 beats per minute. The subject was consis-

Table 6: Changes in weight and blood pressure at waking and bedtime each week from March 22 to June 27, 2025

Weekly	-3/28	-4/04	-4/11	-4/18	-4/25	-5/02	-5/09
Weight(at waking)	70.48	70.17	70.19	69.46	69.34	69.16	69.33
Weight(bedtime)	71.18	70.8	70.7	70.26	69.84	69.96	69.86
Systolic blood pressure (at waking)	110.6	112.1	113	116.6	116.6	123.6	121.3
Diastolic blood pressure (at waking)	81.6	84.3	81.6	84.2	83.7	90.8	92.4
Systolic blood pressure (bedtime)	102.9	99.1	100.5	93.8	98.9	100	97.6
Diastolic blood pressure (bedtime)	75.0	73.6	74.4	69.1	71.2	75.7	71.3
	-5/16	-5/23	-5/30	-6/06	-6/13	-6/20	-6/27
	69.13	69.34	68.76	67.03	66.11	66.61	66.86
	69.8	69.96	69.03	67.56	67.09	67.29	67.48
	123.3	125.1	134.9	121.2	117.8	112.9	120.1
	89.2	93.0	96.8	91.5	89.1	85.3	88.2
	97.4	100.2	117.3	97.5	96.4	92.1	96.5
	72.2	74.1	85.4	74.4	71.0	69.6	71.5

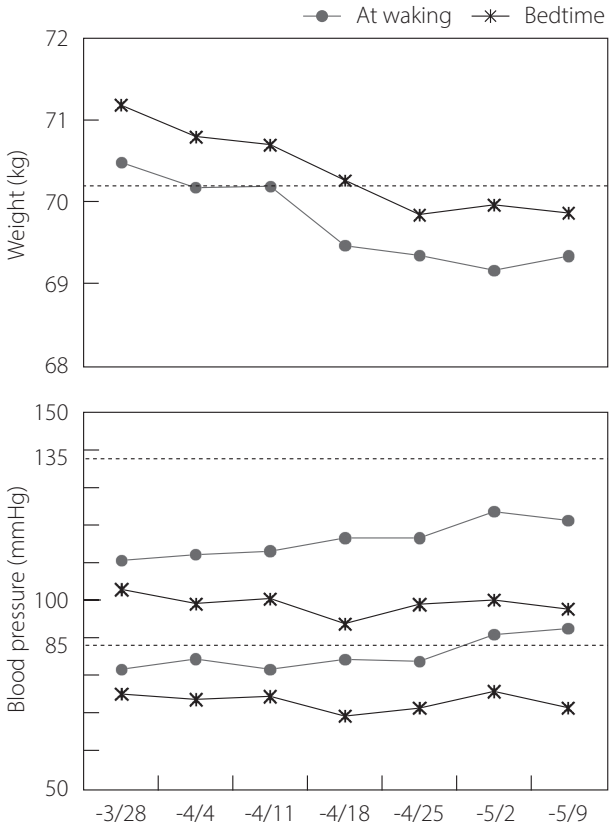

Figure 3: Changes in weight and blood pressure at waking and bedtime each week from March 22 to May 9, 2025

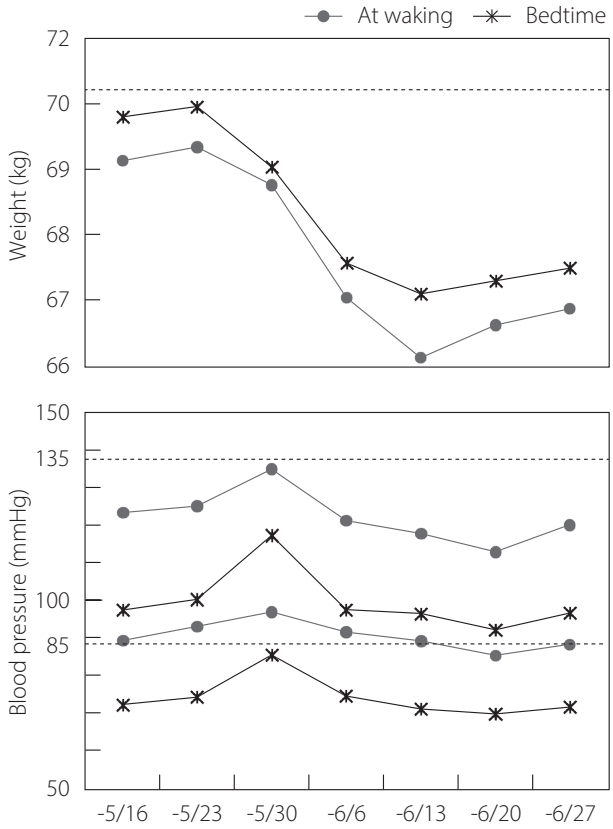

Figure 4: Changes in weight and blood pressure at waking and bedtime each week from May 10 to June 27, 2025

Table 7: Weekly changes in average pulse rate at waking and bedtime

Weekly	-3/28	-4/04	-4/11	-4/18	-4/25	-5/02	-5/09
Pulse rate (at waking)	76.5	77.71	74.86	76.29	71.57	72.07	70.5
Pulse rate (bedtime)	74.93	73.93	74.43	74.43	75.79	75.93	70.14
	-5/16	-5/23	-5/30	-6/06	-6/13	-6/20	-6/27
	74.5	78.79	82.7	79.36	79.79	79.86	78.86
	75.29	76.14	84	76.86	76.86	79.21	78.25

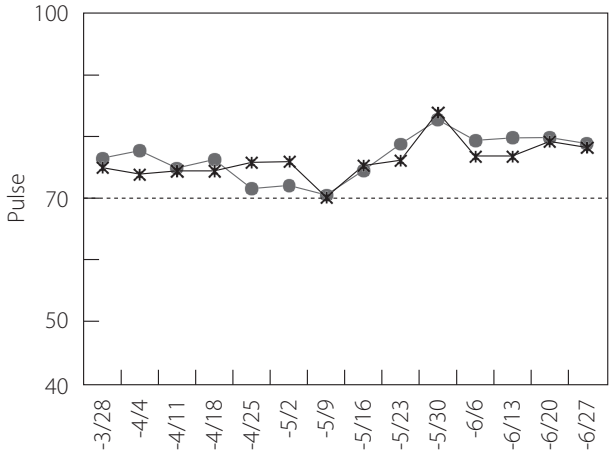

Figure 5: Changes in pulse rate at waking and bedtime each week from March 22 to June 27, 2025

tently high. His pulse rate was especially high during the week of May 30 when his blood pressure was high. There was little difference in pulse rate between at waking and bedtime.

(7) The "non-arrhythmic rate" by week is shown in Table 8. The graph is shown in Figure 6. The number of times that the electrocardiograms were checked for arrhythmia was 28 per week. The number of cases that were not arrhythmia among them, was examined. As a result, it was found that the number was gradually increasing.

7. Conclusion

It is said that improvement cannot be expected merely due to medication in the case of chronic cardiac failure. The cardiac rehabilitation method is a scientifically proven method for strengthening the cardiac, so its effectiveness cannot be denied. Diet therapy has a major impact on the cardiac, blood

Table 8: Changes of "non-arrhythmic rate" by week

Weekly Rate	-3/28	-4/04	-4/11	-4/18	-4/25	-5/02	-5/09
	1/28	2/28	1/28	0/28	1/28	0/28	2/28
	-5/16	-5/23	-5/30	-6/06	-6/13	-6/20	-6/27
	1/28	3/28	1/18	1/28	2/28	4/28	2/26

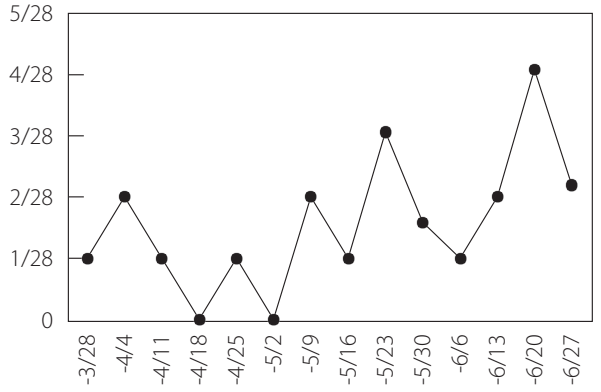

Figure 6: Weekly "non-arrhythmic rate" from March 22 to June 27, 2025

vessels, and blood pressure. Therefore, it can be concluded that "cardiac rehabilitation" and "dietary therapy" were effective based on the results in Figure 6. However, since this is a single case report, there are limitations in generalization. In addition, in this experiment, there was no control group, and the evaluation of the effect was insufficient.

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Received: August 18, 2025
Accepted: September 16, 2025
Published: December 25, 2025

https://doi.org/10.11425/sst.14.193