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Review Article

Cardiac rehabilitation and prescription exercise training for heart failure's patients

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ABSTRACT

Cardiovascular rehabilitation is a multidisciplinary approach that includes exercise instruction, reduction of cardiac risk factors, psychosocial assessment, and result evaluation. Cardiovascular rehabilitation (CR), which includes exercise training, has been shown to significantly improve people with heart failure's quality of life, functional ability, and hospitalizations for heart failure-related conditions. There are so many benefits that are crucial for patients that they must be implemented fully in every health center. The objective for all healthcare practitioners must be to include CR in the regular, normal management of HF patients.

1. Introduction

Due to the disease's recurrent deterioration, heart failure (HF) is a complex clinical illness with a significant cost burden and a major contributor to hospitalizations. In order to lessen the financial burden on patients with HF, appropriate treatment techniques are required, including the management of risk factors to avoid or reduce hospitalizations. In comparison to other countries, Indonesia's heart failure patients were younger, had a low Ejection Fraction, and had diabetes mellitus (DM). The re-hospitalization was 29%, while the mortality in-hospital from 6% to 12%.[1]

Cardiac rehabilitation (CR), a comprehensive, multidisciplinary, long-term intervention provided to patients with HF, comprises illness information, exercise, dietary counseling, risk factor control, and stress management as components. Cardiovascular rehabilitation (CR) is still underutilized despite such good outcomes and cost efficiency.[2]

1.1 Basics of Cardiac Rehabilitation

(World Heart Organization) WHO defines cardiac rehabilitation as " the totality of actions that necessary to affect the disease's underlying cause and also to create the best physical, mental, and social environments, in porpose patients can maintain or regain optimal function in their life and communities through their own efforts. Exercise-based cardiac rehabilitation provides the benefit of improving quality of life, reducing morbidity and mortality, reducing chest pain symptoms and disorders, increasing functional capacity.[3]

Exercise volume has a significant impact on how well cardiovascular mortality or myocardial re-infarction rates decreased by cardiac rehabilitation. Post-myocardial infarction survivors continue to be a crucial demographic for cardiac rehabilitation despite the fact that the target population has grown dramatically over time.

For a number of cardiac conditions, including acute coronary syndromes, CCS, heart failure, cardiac transplant, cardiac pacemakers, and PCI or CABG, the ESC Guidelines recommend cardiac rehabilitation as a class I therapeutic intervention.[4]

Cardiac rehabilitation consists of three phase:[5]

- Early cardiac rehabilitation:

  Phase I: in hospitasl patient (about 4–14 days).
  Phase II: interdisciplinary out patient program under structured supervision (4–12 weeks).

- Late cardiac rehabilitation:

  Phase III: home- or community-based maintenance phase (lifelong).

Over the years, cardiac rehabilitation has transformed from a straightforward monitoring after myocardial infarction to a thorough, interdisciplinary strategy. Similar to this, its indications have grown to include people with a variety of cardiovascular diseases. There can be regional differences in the standards for cardiac rehabilitation since policies and resources that determine the programs are organized and delivered in various nations.[6].

2. Functional Capacity Assesment

2.1 Exercise Test in Cardiac Rehabilitation

2.1.1 Introduction

Exercise stress tests are used to measure the cardiovascular system's response to effort. Exercise testing has historically used to induce ischemia, but the indications have changed throughout time. Cardiopulmonary exercise testing should preferably be carried out since exercise capacity assessment provides essential information for prescribing

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prescribing exercises assistance in programs for cardiac rehabilitation. Exercise tests are typically performed on a treadmill or stationary bike; incremental exercise tests are the gold standard. [7]

2.1.2 Indication and Contraindication

Indications for exercise testing include: physical condition, chronotropic competence, cardiac rhythm disturbances, and functional severity of coronary artery disease and response to implanted cardiac electrical device therapy, and effectiveness of medical treatment. The detection of CAD chest pain or potential symptom analogues in patients. Cardiovascular rehabilitation uses stress tests particularly to:

- Depending on functional ability, coronary reserve, hemodynamic response (BP, HR), and presence of arrhythmias on exertion, the risk categorization of cardiac events during exercise.
- Functional capacity assessment and training recommendations after entry into phase 2 or 3, selection appropriate training model, evaluation progress, planning for work and recreational pursuits after the program is complete. [7]

It is the physician's responsibility to decide whether there are relative contraindications to weigh the risks with the benefits of the information from the test.[7]

2.1.3 Exercise Test Modalities

Exercise tests are often carried out on a cycling ergometer or a treadmill, depending on the type of exercise. Cycle ergometers are less expensive than treadmills, which reflect a more physiological form of exercise. The treadmill handrails should only be used for balance, and it's best to avoid holding onto them when working out to avoid overestimating peak oxygen uptake numbers. Watts (W) are used to calibrate electrically braked cycles and provide a better ECG than treadmills, but their major drawback the test's termination owing to quadriceps muscle exhaustion. Due to this, tests take longer to complete and the maximum oxygen intake achieved is 10-15% lower than on a treadmill. Technically speaking, bicycle tests should be performed correctly, with the seat properly adjusted and the knees extended to around 25 degrees. [3]

2.1.4. Predicted Functional Capacity

METS are used to measure exercise capability. One MET is equal to 3.5 mL/min/kg of body weight, This is a 70 kg, 40 year old man's resting volume oxygen intake per minute (VO2). The proper test protocol is determined by the appropriate evaluation of expected functional capacity.[3].

Formula to predict MET calculation[4]:

1. Morris formula for men: Predicted MET = 18.0 − 0.15 × age (years)
2. Gulati formula for women: Predicted MET = 14.7 − 0.13 × age (years)

To evaluate the intensity of daily living activitiesVeterans Specific Activity Questionnaire and Duke Activity Status Index are two tools that have been created. Duke's Activity Status Index (DASI) consists of 12 questions.[8]

Oxygen uptake= (0.43 × sum of points from positive answers) + 9.6.

2.1.5 Individual Protocol Choices

The choice of the right protocol is important. Depending on the intensity, the exercise test can be maximal (limited to symptoms) or submaximal (predefined). In the cardiac rehabilitation setting, the maximal test is usually preferred. Maximum stress test indicators include:

- Pressure-rate product (maximum heart rate × systolic blood pressure) >20 000;
- Perceived exertion of 18 or more on the Borg scale;
- Patient fatigue.
- The submaximal test is stopped after reaching the goal, eg, in a patient <40 years after myocardial infarction, the test can be stopped after reaching a heart rate of 140 bpm or tolerance equal to 7 METS. In patients >40 years, the test can be discontinued at 130 bpm or with a tolerance of 5 METS.[9]

Table 1. DASI

Is the Patient Able to?	Points
Eat, dress, bath, use the toilet	2.75
Walk indoors	1.75
Walk 1–2 blocks on level ground	2.75
Climb a flight of stairs or walk up a hill	5.5
Run a short distance	8.0
Do dusting, washing dishes	2.7
Do vacuuming, swipe floors, carry groceries	3.5
Do heavy work around the house, e.g., scrubbing floors, lifting or moving heavy furniture	8.0
Do yardwork, e.g., raking leaves, weeding, pushing a power mower	4.5
Have sexual relations	5.25
Participate in moderate recreational activities, e.g., golf, bowling, dancing, doubles tennis, throwing a baseball or football	6.0
Participate in strenuous sports, e.g., swimming, singles tennis, football, basketball, skiing	7.5

The Veterans Specific Activity Questionnaire (VSAQ), estimates aerobic fitness and gauges the highest amount of physical activity performed by the patient are capable of performing.[8]

Table 2. Veterans Specific Activity Questionnaire[8]

MET	The Activity, Which Performed for a Period, Would Typically Cause Fatigue, Shortness of Breath, Chest Discomfort, or a Patients' Will to Stop
1	Eating, getting dressed, working at a desk
2	Taking a shower, shopping, cooking
3	Walking slowly on a flat surface for 1 or 2 blocks, a moderate amount of work around the house, such as vacuuming, sweeping the floors, or carrying groceries
4	Light yard work (i.e., raking leaves, weeding, pushing a power mower), painting
5	Walking briskly, social dancing
6	Heavy carpentry, mowing a lawn with a push mower
7	Carrying 60 pounds, performing heavy outdoor work (i.e., digging, spading soil, etc.), walking uphill
8	Carrying groceries upstairs, moving heavy furniture, jogging slowly on a flat surface, climbing stairs quickly
9	Bicycling at a moderate pace, sawing wood
10	Swimming briskly, bicycling up a hill, jogging 6 miles per hour
11	Carrying a heavy load (i.e., a child or firewood) up 2 flights of stairs
12	Running briskly, continuously (level ground, 8 min per mile)
13	Intermittent sprinting, running competitively, rowing competitively, or riding a bicycle

Treadmill Stress Test Protocol

The Bruce protocol, large and irregular increase in load, only recommended people in strong anticipated functional capability. For people who are unable to engage in strenuous activity, the modified Bruce regimen was developed. The conventional Bruce protocol's first two lower workload stages are included in this process.[10]

Leg Cycle Ergometer Stress Test Protocols

Test protocols for the leg cycle ergometer use body mass to determine functional capability. A graded test typically consists of a 1-2 minute warm-up (either without a load or with a 10 to 20 Watt load), an initial load of 25 Watts (for inactive people or people under 70 kg) or 50 Watts (for active people or people over 70 kg), which is typically increased by 25 Watts every 3 minutes, and finally a cool-down without a load. Following the bicycle stress test, a formula that roughly calculates METs is supplied[10]

2.1.6 Measurements

Measurements during the TRAIN TEST, according to the ACSM, Table 3.[7]

2.2 Cardiopulmonary Exercise Test

Exchange of pulmonary gases, cardiovascular capability, also muscle contraction all influence exercise tolerance. The Fick equation, It claims during maximal exertion, the arteriovenous oxygen differential and cardiac output determine how much oxygen is taken by the body, which is crucial for functional exercise testing. The cardiopulmonary exercise test (CPET) includes measurements of VO2, VCO2, and ventilatory parameters in addition to a symptom-limited exercise test on a treadmill or cycle ergometer. Therefore, CPET is very valuable for evaluating changes in the heart, lungs, and metabolism in response to exercise.[7]

Table 3. Monitoring intervals associated with exercise testing

	Before Test	During Test	After Test
ECG	Monitored continuously, recorded in supine position	Monitored continuously, recorded during the last 15 s of each stage or the last 15 s of each 2 min period (in case of ramp protocols)	Monitored continuously, recorded immediately after exercise, during the last 15 s of the first min of recovery, then every 2 min
HR	Monitored continuously	Monitored continuously, recorded during the last 5 s of each minute	Monitored continuously, recorded during the last 5 s of each minute
BP	Measured and recorded in supine position and posture during exercise	Measured and recorded during the last 15 s of each stage or the last 45 s of each 2 min period (ramp protocols)	Measured and recorded immediately after exercise and then every 2 min
RPE	RPE scale should be explained	Recorded during the last 15 s of each stage or every 2 min (ramp protocols)	Peak exercise value to be obtained, not measured in recovery

Table 4. Indications for cardiopulmonary exercise testing[11]

Class	Indication
I (indicated)	1. Evaluation of exercise capacity and response to treatment in patients with heart failure, who are being considered for heart transplantation 2. Differentiation of cardiac versus pulmonary limitations as a cause of exercise-induced dyspnea or impaired exercise capacity when the cause in uncertain
IIa (good supportive evidence)	Evaluation of exercise capacity when indicated for medical reasons in patients for whom the estimates of exercise capacity from exercise test time or work rate are unreliable
IIb (weak supportive evidence)	1. Evaluation of the patient's exercise tolerance response to specific therapeutic interventions Determination of the intensity for exercise training as part of comprehensive cardiac rehabilitation
III (not indicated)	Routine use to evaluate exercise capacity

2.2.1 Indications

The ACC-AHA propose that CPET be widely used in functional assessments of heart failure patients to establish the severity of the condition, to ease prescription and identify candidates for transplantation [11]

2.2.2 Parameters

CPET enables the evaluation of cardiac and ventilatory parameters. The main CPET parameters :[3]

Peak Oxygen Uptake

The oxygen that is removed from the air and inhaled every time, measured milliliters per minute (mL/min), is frequently standardized for body weight (mL/kg/min). The greatest indicator of maximum oxygen uptake has historically been reaching a distinct plateau in oxygen consumption because oxygen uptake rises linearly with work. The indicator of aerobic capacity and the gold standard for evaluation of cardiorespiratory fitness is maximal oxygen uptake. In actuality, reaching this plateau before symptoms and stopping exercise may not be possible. Maximum oxygen absorption is determined by age, sex, weight, height, fitness level, and ethnicity. Additionally, training and patient motivation may have an impact. An oxygen consumption of less than 14 mL/kg/min was utilized as the cut off acceptability for heart transplant in an analysis of 114 ambulatory individuals in heart failure for the procedure.[3]

Respiratory Exchange Ratio (RER)

The VCO_2/VO_2 is known as RER is accurate non invasive measure of exercise volume. RER rises during exercise as a result of either hyperventilation or buffering lactic acid. Resting RER is about 0.8, and RER > 1.0 show maximal exercise effort.[3]

Anaerobic Threshold (AT) or Lactate Threshold

Aerobic metabolism predominates when the incremental activity is light to moderate, and the blood lactates level stays constant (or very slightly rises). Expiratory ventilation (VE) increases linearly with oxygen intake during this first, aerobic phase of CPET, which lasts until 50–60% of peak oxygen uptake is reached. Usually, the first ventilatory threshold is reached about 60 to 70% of the maximum oxygen absorption. As a result, AT predicts when metabolic acidosis will start to occur, and it is connected to the oxygen uptake at which it does. As such, AT should be stated as a percentage of the expected value of maximal oxygen uptake. The anaerobic threshold can be determined using a variety of approaches. If present, EOV should have an amplitude of >15% and should last for 60% of the exercise test.[3]

2.3 Walking Tests

2.3.1 Six-Minute Walk Test

The six-minute walking test (6 MWT) measures the distance a patient can walk briskly in six minutes. The test should be carried out in an area with minimal traffic, optimally in a closed corridor, but can also be carried out outdoors. A six-minute walk test on a treadmill is not recommended, as the patient will be unfamiliar with the machine and achieve much lower walking distances. The six-minute walking test is a simple and safe method of assessing functional capacity. SMWT results should be viewed as an adjunct to traditional exercise testing, as the majority of patients do not walk at their own pace to their maximal exercise capacity. SMWT has been used to qualify patients for exercise training after complete revascularization or after cardiac surgery. [8]

To use the percentage of anticipated SMWT distances, Enright and Sherill created reference formulae for men and women.[4]

- For women: (2.11 × height in cm) − (2.29 × body mass in kg) − (5.78 × age) + 667 m.
- For men: (7.57 × height in cm) − (5.02 × age) − (1.76 v body mass in kg) + 309 m.

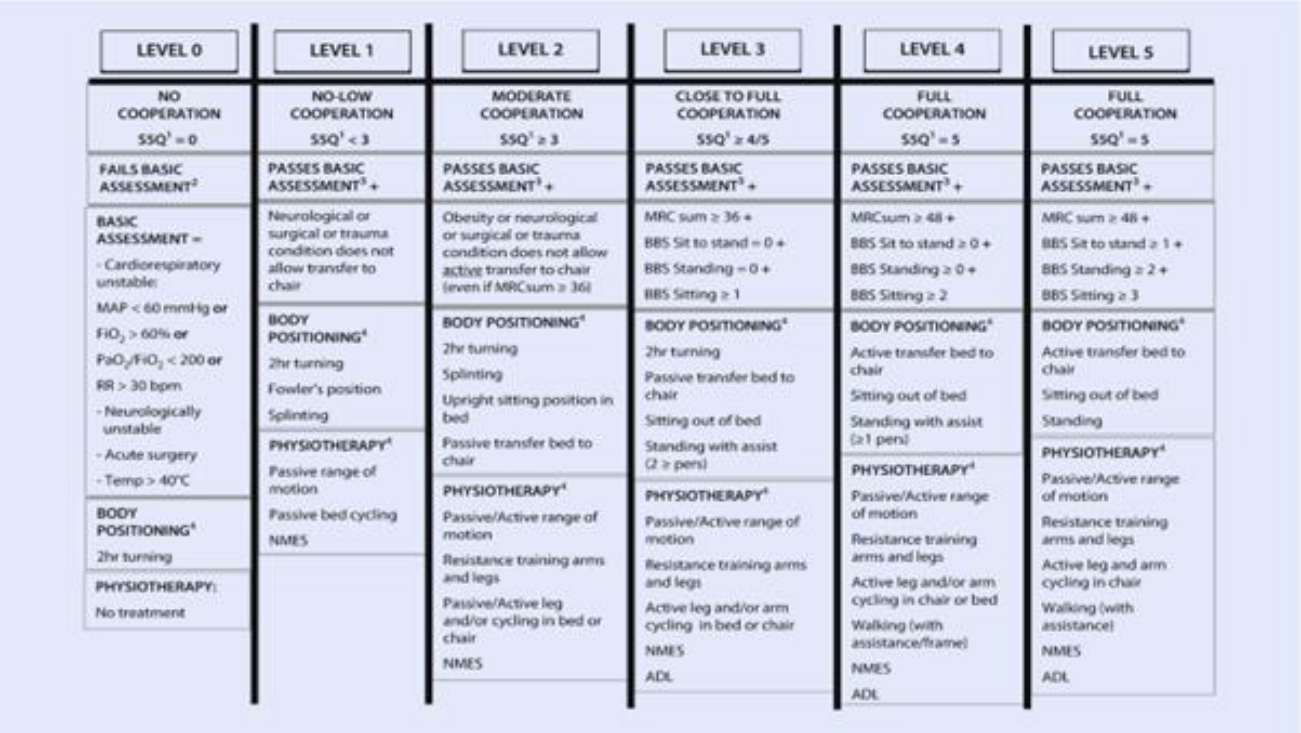
2.3.2 The Incremental Shuttle Walking Test

The incremental shuttle walk test (ISWT) involves going back and forth between two cones placed 0.5 m from either end of a 10 m course while being externally timed and symptom-limited. Up until the patient becomes too exhausted to continue or is unable to sustain the requisite speed, the beginning walking speed is gradually increased each minute. The test result is the quantity of completed shuttles, or the overall ISWT distance traveled. There doesn't appear to be a learning effect in the ISWT, in contrast to the SMWT.[12]

2.4 Safety of Exercise Testing

Rare cardiovascular events can occur when exercising on a treadmill or leg cycle ergometer. The patient had to feel too out of breath or exhausted to continue at the needed speed, the test had to be finished within the allotted time, the patient had to hit 220 – age in years, and estimated submaximal pulse (85% of estimated maximum pulse based on age), or the patient had to pass all test levels. No significant incident was reported for either the ISWT or training, as was expected. Silent ischemia (27% of ISWT) was the clinically significant occurrence, then ectopic beats in the atrium and ventricular chambers (18% and 15%). The tiny sample population used, however, necessitates additional research.[3]

Table 5. The Leuven protocol[17]



3. Phases of Cardiac Rehabilitation

Cardiac rehabilitation typically comprises three phases:[13]

3.1 Phase 1 – Early Mobilization

Following acute cardiac episodes, bed rest and immobilization have long been advised as the standard of care. Early mobilization refers to starting mobilization procedures as soon as clinical stability is attained, usually within 1-2 days after admission. It has a considerable impact on both the length of hospital stays and the rate of readmission.[13,14]

After 12-48 hours of clinical stabilization, Phase I, or the inpatient phase, should commence. This usually happens in the coronary care unit, critical care unit, postoperative ward, or cardiac rehabilitation ward.[15]

Phase I comprises:[16]

- Quick patient mobilization carried out by a physiotherapist under the direction of a supervising physician, sometimes an intensive care unit physician.
- Personal cardiovascular risk factor identification.
- Plan for each person to facilitate changes in lifestyle.
- Short-term instruction through individual conversations and the distribution of leaflets with information about cardiac problemes.
- Questionnaires for psychological screening evaluation.
- A discharge home activity schedule that calls for walking, weightlifting (except for patients with contraindications, especially in post-cardiac surgery patients), going back to work, and restarting sexual engagement.

Phase II recommendation.

The methodical step-up method for progressive early mobilization, or the Leuven protocol, has been suggested. It consists of six levels of mobilization based on the degree of cooperation. [17]

3.2 Phase 2 – Supervised Exercise Training

As soon as feasible after discharge, ideally within two weeks, Phase II should begin. Phase II typically lasts up to 12 weeks. A doctor will carry out an initial assessment and risk stratification prior to the start of an exercise training program. The level of functional ability, the persistence of residual ischemia, and the occurrence of arrhythmias all play a role in risk classification. Optimization of medical therapy, smoking cessation program, career counseling, and stress management are all included in Phase II's extensive teaching and counseling addressing modifiable cardiovascular risk factors.[16]

3.2.1 Early Assessment

A clinical evaluation, which includes a medical history interview and tests including resting 12-lead ECG, laboratory tests, resting TTE, 24-hour ECG monitoring, and functional capacity assessments, are included in the entry assessment. Detection of major rhythms, heart rate, ischemia, or conduction anomalies is possible with a resting ECG.[18]

Exercise stress testing procedures (cardiopulmonary exercise testing is preferred for individuals with congenital heart disease, heart failure, or heart transplants) should be modified to the patient's health. If exercise stress testing is not possible, a six-minute walk test is advised.The following useful cardiac rehabilitation entrance checklist was given by Abreu et al.[18]

3.2.2 Exercise Prescription

The following elements should be included in exercise instruction:[19]

a. Aerobic exercises
b. Resistance
c. Flexibility
d. Neuromotor

An exercise training session comprises:[20]

- Warm-up, often 5–10 minutes of light–moderate exercise at 30–40% of maximum heart rate, or 11 points on the RPE Borg Scale. The warm-up prevents the abrupt rise in catecholamine levels and enables the body to adapt to the physiological demands gradually An intensity level of 40% of the heart rate reserve (or Borg scale 10) should be obtained before the end of the warm-up period. Activities that raise heart rate should be included in the warm-up (for 3-5 minutes), such as stationary marching, walking, or light cycling. The primary muscular groups can then be stretched for 3-5 minutes, followed by a rewarm-up.[20]

Table 6. The AACVPR risk stratification.[13]

Parameter	Low Risk	Moderate Risk	High Risk
Left ventricular ejection fraction	LVEF 50% or more	LVEF 40%–49%	LVEF < 40%
Complex ventricular dysrhythmia	Absent at rest or during exercise testing and recovery		Present at rest or during exercise testing and recovery
Angina or other symptoms (unusual shortness of breath, lightheadedness, or dizziness)	Absent during exercise testing and recovery	Present only at high level of exertion (7 METS or more)	Present at low levels of exertion (≤5METS) or during recovery
Hemodynamics during exercise testing and recovery	Normal hemodynamics		Abnormal hemodynamics during exercise testing (i.e., chronotropic incompetence or flat or decreasing systolic blood pressure with increasing workload) or during recovery (severe post-exercise hypotension)
Ischemic ECG changes	None	ST-segment depression < 2 mm	ST-segment depression more than 2 mm
Functional capacity	7 METS or more 100 watts or more	5–6.9 METS 75–100 watts	<5 METS < 75 watts
Clinical data	Uncomplicated myocardial infarction or a revascularization procedure Absence of congestive heart failure Absence of signs or symptoms of post-event/ post-procedure ischemia		History of cardiac arrest Complicated myocardial infarction or revascularization procedure Presence of signs and symptoms of post-event/post – procedure ischemia Presence of congestive heart failure
Clinical depression	Absent		Present
	All characteristics listed must be present for patients to remain low-risk	One or more of these findings places the patient at moderate risk.	One or more of these findings places the patient at high risk.

- A conditioning phase that lasts 20 to 60 minutes. A treadmill, for example, can be used to complete the conditioning phase. Alternatively, circuit (station) training can be used. Circuit training involves working out on aerobic stations (often for 30 seconds to two minutes each), followed by resistance exercises at an active or passive recovery station.[20]

- A 5- to 10-minute cool-down period that involves light-to moderate-intensity workouts enables the blood pressure and heart rate to gradually return to normal. A gradual cool-down phase need. Essentially, the warm-up should be reversed during the cool-down phase. Following the cool-down period, all patients should be under supervision for at least 15 minutes. [20,21]

Exercise training parameters should be appropriate the FITT-VP principle: frequency, intensity, time (duration), type, volume (total amount), and progression.[20,21]

3.3 Phase 3 – Long Term Exercise Training

After patients have successfully completed phase II of rehabilitation, they should be offered phase III rehabilitation, also known as the maintenance phase, as a long-term (lifelong) maintenance phase. It can be carried out as a home exercise program or in a CR or community center. Some nations offer hybrid cardiac rehabilitation with remote monitoring. Patients who have finished the phase II treatment require a follow-up evaluation by a cardiac specialist.[16,22]

It is crucial to provide a personalized physical activity program that considers the patient's cardiorespiratory fitness level and underlying heart disease. Long-term commitment to physical exercise should be supported by the use of digital technologies, such as wearable physical activity monitors. The Rudnicki ABC model for phase III, which uses similar guidelines to those for phase II, is advised by the authors. those with high risk and low, intermediate, or very low functional capacity should be managed similarly to model D of phase II CR, as should those with intermediate risk and very low functional capacity. [23]

Table 7. The Rudnicki ABC table.[23]

	Duration	Frequency	Exercise Type	Intensity
A				
Stage 1	2-3 months 3 x 45 min/week	3 x 45 min/week	Medically supervised training on cycle ergometer or treadmill, interval or continuous Calisthenics at gym	60%-80% of heart rate reserve
Stage 2	3 months	3 x 45 min/week	Exercise training on cycle ergometer or treadmill, interval or continuous Calisthenics at the gym Resistance circuit training. 2-3 sets	60%-80% of heart rate reserve
Stage 3	Unlimited	3 x 45-60 min/week	Walking, cycling, swimming	60%-80% of heart rate reserve
B				
Stage 1	2-3 months	3 x 30-40 min/week	Medically supervised interval training (initially with ECG monitoring) on cycle ergometer or treadmill Calisthenics at gym	40%-50% of heart rate reserve
Stage 2	3 months	3 x 45 min/week	Medically supervised interval exercise training on cycle ergometer or treadmill Calisthenics at gym Resistance circuit training. 1 set	50%-60-% of heart rate reserve
Stage 3	Unlimited	3 x 45-60 min/week	Walking, cycling.	Stage 3 Unlimited 3 x 45-60 min/week Walking, cycling 50%-60% of heart rate reserve
C				
Stage 1	2-3 months	3 x 30 min/week	Individual, medically supervised (with continuous ECG monitoring) interval exercise training on cycle ergometer or treadmill Calisthenics at gym	40%-50% of heart rate reserve
Stage 2	3 months	3 x 45 min/week	Individual, medically supervised interval exercise training on cycle ergometer or treadmill Calisthenics at gym	50%-60% of heart rate reserve
Stage 3	Unlimited	3 x 45 min/week	Walking, cycling, swimming, dancing, gardening	50%-60% of heart rate reserve

4. Exercise Prescription in Heart Failure Patient

Heart failure's patient often have low exercise tolerance due to decreased cardiac output, poor vasodilation, and elevated systemic vascular resistance. Patients can be divided into groups based on their level of physical capability:[24]

- Patients whose functional capacity has been significantly impaired (peak oxygen uptake in CPET < 10 mL/kg/min, SMWT distance < 300 m).
- moderate functional impairment (peak oxygen uptake 10–18 mL/kg/min, SMWT distance 300–450 m).
- good functional capacity (peak oxygen uptake > 18 mL/kg/min, SMWT distance > 450 m).

Due to the benefits gained both during and after admission, including improved symptoms, better quality of life, together with lower hospitalization rates, for all heart failure patients diagnosed in NYHA classes I–III, regardless of the EF from echocardiography , must be referred a cardiac rehabilitation program. An RCT study conducted by Belardinelli in 2005 that the phase II rehabilitation program increased peak work by 15 watts, exercise duration by 2.3 minutes, and distance during SMWT by 40 meters.[25]

4.1 Phase 1 (In Patient phase)

The patient's fitness regiment has to start during therapy and be maintained during outpatient treatment. As soon as the patient's health improves, after the congestive signs have subsided and the hemodynamic are stable, it is necessary to start with modest mobilization (gymnastic workouts with simple motions, without weights or equipment). Body flexibility and strength will increase as a result. It is also recommended to perform resistance exercises for minor muscle groups, but the starting intensity should be kept under 30% of the maximum one repetition. The importance of breathing exercises, or exercises for the respiratory muscles, cannot be overstated. The patient's hemodynamic state and the disease's stage define the suggested course of action.[26]

4.2 Phase 2 (Outpatient Phase)

Since each person's etiology of heart failure is unique, there is no formal consensus that governs a particular pattern for rehabilitation therapy for heart failure patients. Prior to beginning an exercise program, it is crucial to understand the etiology of heart failure, current medication, and level of functional capacity. Using a modified Naughton or Bruce protocol on a treadmill or an extra protocol or a bicycle ergometer in increments of 5–10 W/min, the first intensity based on the CPET. Before beginning the phase 2 program, the SMWT can be used as an alternative to the submaximal test if CPET is not feasible.[27]

4.3 Exercise Prescription

According to the ESC Heart Failure 2021 recommendations, aerobic activity at a class 1A suggested level will increase functional capacity to the greatest extent. Patients with heart failure must also take into account muscle loss, notably in the skeletal and respiratory systems. Consequently, it's imperative to combine cardiovascular activity with muscle-building and breathing activities.[3]

4.3.1 Endurance aerobic training (continuous and interval)

aerobic exercise is frequently performed at moderate to high intensities under continuous aerobic energy. It permit to finish lengthy training that can last up to 45–60 minutes. It is well known because it is simple to teach and easy for patients to perform on a treadmill or cycle ergometer. Even more worn-out individuals, to start out slowly and increase the intensity (, at low intensity for 5–10 minutes 2x/week). With a goal of 20 to 60 minutes, three to five days a week, at a moderate to high effort, and endless program, training sessions are added more frequently if well tolerated. The gold standard for determining intensity of exercise involves using physiological indicators of metabolic effort intensity that can be directly assessed, such as peak oxygen consumption (VO2peak),

Table 8. Exercise prescription for those with chronic heart failure [3]

Functional Capacity Level	<65 Years Active	<65 Years Sedentary	>65 Years Active	>65 Years Sedentary
VO_2 peak < 10 mL/kg/min or 6 MWT < 300 m	Continuous endurance Respiratory Resistance Low-intensity interval	Continuous endurance Respiratory Resistance Low-intensity interval	Continuous endurance Respiratory Resistance Low-intensity interval	Continuous endurance Respiratory Low-intensity interval
VO_2 peak 10–18 mL/kg/min or 6 MWT 300–450 m	Continuous endurance Respiratory Resistance Interval	Continuous endurance Respiratory Resistance	Continuous endurance Respiratory Resistance	Continuous endurance Respiratory
VO_2 peak > 18 mL/kg/min or 6 MWT > 450 model	Continuous endurance Respiratory Resistance High-intensity interval	Continuous endurance Respiratory Resistance High-intensity interval	Continuous endurance Respiratory Resistance High-intensity interval	Continuous endurance Respiratory Resistance High-intensity interval

during a symptom-limited cardiopulmonary exercise test. Training intensity is frequently specified in relation to VO2peak, VO2reserve (VO2R), or at the anaerobic threshold (when visibly detected) in order to prevent overtraining. For training intensities, a starting point of 40–50% and an increase to 70–80% of the VO2peak or VO2R percentage are advised. It is recommended to use a "training HRR range" of 40-70% HRR and 10/20-14/20 of the Borg RPE. [3]

4.3.2 Resistance Training

Resistance/strength training (RST) involves making muscle contractions in opposition to certain opposing forces, such as lifting weights. It builds bone density, tones and strengthens muscles, and gradually overworks the musculoskeletal system. In order to prevent the wasting syndrome, it has been proposed as an anabolic intervention.Resistance training often incorporates a work-to-rest ratio of 1:2 and consists of 30 to 60 seconds of exercise followed by 1 to 2 minutes of relaxation. The progression of resistance training should be phasic for full exercise progression, at least 3–4 weeks are needed.[3]

4.3.3 Respiratory Training

In studies involving CHF patients, inspiratory muscle training seems to improve quality of life and exercise capacity, who start off with inspiratory muscular weakness (IMW). Therefore, it is advised to check for IMW on a regular basis, and it may be beneficial to combine targeted inspiratory muscle activity with regular endurance training.[24]

It's important to exercise your inhalatory muscles, especially while you're a patient. Usually, it's recommended to aim for 60% of your maximum inspiratory mouth pressure, and to increase by 30% every 7 to 10 days. This type of training lasts for eight weeks, taking place 3-5 days a week for 20 minutes each day.[3]

4.4 Exercise training in special populations

There are many different causes of heart failure, some of which require unique considerations during rehabilitation. The following are some specific recommendations made for patients of heart failure with comorbidities:

4.4.1 Acute Coronary Syndrome

Following an acute MI, patients who were referred underwent detailed assessments cardiac rehabilitation. A meta-analysis of 36 randomized controlled studies involving 6111 myocardial infarction patients revealed a correlation between cardiovascular rehabilitation and a 36% reduction in cardiac death, a 26% reduction in overall mortality, and a 47% reduction in the risk of reinfarction events.. Two proposed mechanisms for reducing mortality include ischemia-induced preconditioning and decreased sympathetic tone followed by enhanced parasympathetic tone.[28]

The in-patient phase may start 48 hours after the infarct or after 12 hours following an acute event, when patients can gradually move in bed and are receiving revascularization without any issues. Patients with heart failure typically adhere to the same phase 1 mobility protocol.[29]

A phase II program should include patient assessment after acute coronary syndrome, a functional capacity evaluation based on a symptom-limited exercise test, an assessment of angina threshold, exercise training, nutritional advice, body mass control, lipid , blood pressure, quitting smoking, and psychosocial [30]

Patients must be divided into three groups before starting exercise phase II: low risk (no high clinical risk and no high thrombotic risk), intermediate risk (high thrombotic risk like multivessel disease, incomplete or no revascularization, DM, CRF, peripheral arteriopathy, history of angina or previous MI), and high risk (patient with high thrombotic and high clinical risk like: Ki10). Low risk patient typically involves 2-3 outpatient sessions per week and 5–6 residential and hybrid cardiac rehabilitation sessions per week. Most sessions run between 30 and 60 minutes. aerobic exercise that is moderately intense (4-6 METs, or 12/20–14/20 on the Borg scale; peak oxygen intake, heart rate, and heart rate reserve at 45–59%, 55–69%, and 40–59%, respectively). Patients at intermediate and high risk should start exercising at a level that is 40% of their maximum heart rate. Recent studies have focused on the benefits of high- and maximal-intensity interval training for those with ACS. Patient doing exercises at 95-100% of their maximum heart rate reserve or at 85% of their heart rate reserve (high intensity training) after two weeks of moderate intensity training (as an adaptation period), then continued four weeks of three days every week.[3]

4.4.2 CABG

An observational study of 846 individuals who underwent CABG and were followed for an average of 9 years indicated a mortality from all causes was reduced by 12% absolute risk and 46% relative risk. Age, gender, previous myocardial infarctions, or diabetes did not have any impact on these outcomes. Following the same guidelines as with other heart failure patients, early mobilization following surgery with combining resistance, resistance training, and muscular contraction were done.[3]

4.4.3 Valvular Surgery

The increase of functional capacity and LV systolic performance is prolonged throughout time as a result of valve surgery, which is frequently performed during the symptomatic period, usually in advanced heart failure.[11] Following valve surgery, the overall guidelines for the cardiac rehabilitation program are similar to those for post-CABG. Based on the specific rehabilitation strategy: The patient's clinical condition before having valve problem surgically corrected (symptom persistence, hemodynamic irregularities, heart rhythm, embolic, orthopedic and vascular disorders) The type , wound status, and complications.

4.4.4 Implantable Cardiac Electrical Device

Permanent pacemaker, CRT, or ICDs are put in a sizable portion of patients referred to cardiac rehabilitation. Cardiovascular rehabilitation specialists must pay special attention to the individuals with implanted cardiac electrical devices receive exercise instruction because they must have sufficient knowledge of the devices' appropriate operation and monitor the exercise training.[31]

When a patient is admitted to phase II, the placement of the device should be determined after a wound inspection, the rationale for the implantation is examined, and any underlying cardiac illness, including past incidents, is evaluated. Phase II of PPM should start with the stimulation parameters being assessed. If patients have any symptoms (such as palpitations, syncope, or dizziness) linked to incorrect stimulation, they should inform the cardiac rehabilitation staff.[31]

Recommendations for exercising with cardiac electrical devices The receivers should combine the continuous endurance or interval model, last 30-60 minutes, and conducted 3-5 days per week, and follow the recommendations for heart failure patients. After six weeks, resistance training can start. This entails 2-3 sets of 10–12 repetitions each, at perceived level of effort of 12–15, an emphasis on shoulder motions on implant's site.[3]

5. Conclusion

Heart failure practice guidelines support cardiac rehabilitation as a Class 1A indication because it is advantageous for individuals with heart failure. The norm for treating heart failure patients in all healthcare facilities should include cardiac restoration, according to multidisciplinary health workers like doctors. Practical advice as well as measures to boost referrals, adherence, and funding for cardiac rehabilitation should keep growing to help patients with heart failure complete the program. To effectively treat cardiac rehabilitation therapies, patients with varied etiologies of failure must be quickly diagnosed.

6. Declaration

6.1 Ethics Approval and Consent to participate
Not applicable.

6.2. Consent for publication
Not applicable.

6.3 Availibility of data and materials
Data used in our study were presented in the main text.

6.4 Competing interests
Not applicable.

6.5 Funding Source
Not applicable.

6.6 Authors contributions
Idea/concept: ZF. Design: ZF. Control/supervision: CTT. Data collection/processing: ZF. Analysis/interpretation: ZF, CTT. Literature review: ZF. Writing the article: ZF. Critical review: CTT. All authors have critically reviewed and approved the final draft and are possible for the content and similarity index of the manuscript.

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