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IN THE CARDIOVASCULAR REHABILITATION UNIT

Assessment, Individualized Interventions, and Treatment Adherence

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TABLE OF CONTENTS

CHAPTER I. THE APPLICATION OF CARDIOVASCULAR PREVENTION AS AN ESSENTIAL COMPONENT OF RECOVERY 6

Laura Crăciun

Ana-Maria Pah

1. INTRODUCTION 6
2. CARDIOVASCULAR RISK FACTORS—THE CENTRAL OBJECTIVE OF PREVENTION 12
3. ASSESSMENT AND STRATIFICATION OF OVERALL CARDIOVASCULAR RISK 20
4. INDIVIDUALIZED STRATEGIES FOR REDUCING CARDIOVASCULAR RISK 31
5. CARDIOVASCULAR REHABILITATION - FROM PREVENTION RECOMMENDATIONS TO CLINICAL PRACTICE 57

ABBREVIATIONS 61

BIBLIOGRAPHY 62

CHAPTER II. CARDIOVASCULAR REHABILITATION PROTOCOLS FOR COMPLEX CASES 64

Laura Crăciun

1. INTRODUCTION 64
2. GENERAL PRINCIPLES OF REHABILITATION FOR COMPLEX PATIENTS 70
4. THE COMPLEX CARDIOVASCULAR PATIENT—SPECIFIC ASPECTS OF REHABILITATION 79
5. RISK STRATIFICATION AND EXERCISE SAFETY IN COMPLEX PATIENTS 90
6. NUTRITIONAL STATUS AND SARCOPENIA IN PATIENTS WITH COMPLEX CARDIOVASCULAR DISEASE 91
7. CARDIAC TELEREHABILITATION IN COMPLEX CASES 92
8. CASE STUDIES 93
9. CONCLUSIONS 95

Appendix 1. Guideline for the Initial Assessment of a Complex Patient 97

Appendix 2. Ethical and Legal Guidelines for the Rehabilitation of Complex Patients 98

Appendix 3. Sample Exercise Session Monitoring Form 99

ABBREVIATIONS 100

BIBLIOGRAPHY 102

CHAPTER III. LEFT VENTRICULAR PERFORMANCE—THE TARGET OF CARDIOVASCULAR RECOVERY 103

Laura Crăciun

1. INTRODUCTION 103
2. PHYSIOLOGY OF LEFT VENTRICULAR FUNCTION 105
3. PATHOPHYSIOLOGY OF LEFT VENTRICULAR FUNCTION 108
5. THE EFFECTS OF PHYSICAL TRAINING ON LEFT VENTRICULAR REMODELING 112
6. GENERAL PRINCIPLES FOR PRESCRIBING PHYSICAL EXERCISE BASED ON LEFT VENTRICULAR PERFORMANCE 114

7. ORGANIZATION OF ACTIVITIES IN THE RECOVERY UNIT 116
8. FROM PHASE I TO PHASE III: CARDIOVASCULAR RECOVERY GUIDED BY LEFT VENTRICULAR FUNCTION 119
9. MONITORING LEFT VENTRICULAR FUNCTION DURING THE REHABILITATION PROGRAM 120
10. CHARACTERISTICS OF PATIENTS WITH SEVERE VENTRICULAR DYSFUNCTION 132
11. CARDIOPROTECTIVE PHARMACOLOGICAL THERAPY AND ITS INTERACTION WITH PHYSICAL EXERCISE 133
12. THE ROLE OF PATIENT EDUCATION IN PRESERVING CARDIAC FUNCTION 135
13. WORKSHEETS 136
14. CASE STUDIES 137
15. THE ROLE OF NUTRITION AND CVR CONTROL IN PRESERVING LEFT VENTRICULAR FUNCTION 139
16. EMERGING TECHNOLOGIES IN MONITORING LEFT VENTRICULAR FUNCTION 140
Appendix 1. Expanded Initial Assessment Form Focused on Left Ventricular Performance 141
Appendix 2. Guideline for Emergency Procedures During a Drill 142
Appendix 3. Quick Guide for the Preliminary Interpretation of LV Performance Parameters 143
Appendix 4. Sample of a Completed Initial Evaluation Form 144
ABBREVIATIONS 145
BIBLIOGRAPHY 146

CHAPTER IV. RECOVERY OF PATIENTS WITH VASCULAR DISEASE IN THE ERA OF REVASCULARIZATION 147

Laura Crăciun

1. INTRODUCTION 147
2. PATHOPHYSIOLOGY OF ATHEROSCLEROSIS AND SYSTEMIC VASCULAR DISEASE 149
3. CHRONIC CORONARY SYNDROME (CCS) IN THE ERA OF REVASCULARIZATION 151
4. PERIPHERAL ARTERIAL DISEASE (PAD) 153
5. ATHEROSCLEROTIC STROKE 155
6. THE PATIENT WITH MULTIVASCULAR ATHEROSCLEROTIC DISEASE 157
7. INITIAL EVALUATION OF PATIENTS WITH EXTENSIVE ATHEROSCLEROTIC DISEASE 158
8. REHABILITATION IN PATIENTS WITH CHRONIC CORONARY SYNDROME (CCS) 161
9. REHABILITATION IN PATIENTS WITH PERIPHERAL ARTERY DISEASE (PAD) 164
10. POST-ISCHEMIC STROKE RECOVERY – CARDIOVASCULAR COMPONENT 167
11. NUTRITION IN PATIENTS WITH MULTIVASCULAR ATHEROSCLEROTIC DISEASE 170
12. INDIVIDUALIZED RECOMMENDATIONS FOR PHYSICAL TRAINING IN PATIENTS WITH MULTIVESSICULAR ATHEROSCLEROTIC DISEASE 171

13. MONITORING AND WARNING SIGNS SPECIFIC TO EACH AFFECTED VASCULAR TERRITORY 175
14. INTENSIVE SECONDARY PREVENTION IN PATIENTS WITH MULTIPLE VASCULAR DISEASES 178
15. PSYCHOLOGICAL AND COGNITIVE ASPECTS 187
16. PRACTICAL ORGANIZATION IN THE REHABILITATION UNIT 188
17. WORKSHEETS 189
18. CASE STUDIES 190
19. TELEREHABILITATION FOR PATIENTS WITH VASCULAR DISEASE 192
Appendix 1. Expanded Initial Assessment Form for the Multivascular Patient 193
Appendix 2. Guideline for Emergency Care of Patients with Cerebrovascular Disease 194
Appendix 3. Sample Completed Multivascular Screening Form 195
BIBLIOGRAPHY 198

CHAPTER V. RECOVERY OF PATIENTS WITH HEART FAILURE 199

Laura Crăciun

1. INTRODUCTION 199
2. PATHOPHYSIOLOGY OF HEART FAILURE AND VENTRICULAR REMODELING 201
3. CLASSIFICATION AND STAGING OF HF—PRACTICAL IMPLICATIONS FOR CARDIOVASCULAR REHABILITATION 202
4. COMMON COMORBIDITIES IN PATIENTS WITH HF 206
5. INITIAL EVALUATION OF THE PATIENT WITH HF 207
6. RECOMMENDATIONS FROM THE 2026 ESC GUIDELINES ON CARDIOVASCULAR REHABILITATION REGARDING AEROBIC INTENSITY 209
7. RECOVERY IN PATIENTS WITH LOW EJECTION FRACTION (HFrEF) 214
8. RECOVERY IN PATIENTS WITH PRESERVED EJECTION FRACTION (HFpEF) ... 226
9. RECOVERY AFTER CARDIAC SURGERY 231
10. MANAGEMENT OF RISK FACTORS AND PHARMACOLOGICAL TREATMENT 232
11. MONITORING AND WARNING SIGNS 234
12. PSYCHOLOGICAL AND COGNITIVE ASPECTS 235
13. CASE STUDIES 236
14. NUTRITION IN PATIENTS WITH HEART FAILURE 238
15. CARDIOLOGY AND ONCOLOGY AND TREATMENT-INDUCED HEART FAILURE 239
16. ETHICAL ISSUES IN ADVANCED HEART FAILURE 240
Appendix 1. Expanded Initial Assessment Form 241
Appendix 2. Detailed Monitoring Form for the Drill Session 242
Appendix 3. Pre-session checklist for patients with heart failure 243
ABBREVIATIONS 244
BIBLIOGRAPHY 245

CHAPTER I. THE APPLICATION OF CARDIOVASCULAR PREVENTION AS AN ESSENTIAL COMPONENT OF RECOVERY

Laura Crăciun
Ana-Maria Pah

1. INTRODUCTION

- **The Epidemiological Context of Cardiovascular Diseases**

Cardiovascular diseases (CVD) remain the leading cause of mortality and morbidity worldwide, accounting for approximately one-third of all deaths recorded annually globally. According to data from the World Health Organization, approximately 18 million people die each year from cardiovascular diseases, and most of these deaths are caused by coronary heart disease and stroke. A significant proportion of these deaths occur prematurely, in people under the age of 70 who are still in their working years.

In Europe, cardiovascular diseases—particularly coronary heart disease and stroke—continue to represent a major burden on health care systems. This burden manifests itself in several ways:

- **direct costs**, related to hospitalizations, interventional and surgical procedures, long-term medication, and implantable devices;
- **indirect costs**, related to lost productivity, temporary or permanent inability to work, and early retirement;
- **human and social costs**, represented by disability, reduced quality of life, and dependence on family and social services.

The distribution of cardiovascular diseases is not uniform across the continent. Countries in Central and Eastern Europe, including Romania, have significantly higher rates of cardiovascular mortality than countries in Western and Northern Europe. These differences reflect both a higher prevalence of risk factors (high blood pressure, smoking, dyslipidemia, obesity, diabetes, excessive alcohol consumption, and a sedentary lifestyle) and disparities in access to prevention, early diagnosis, and rehabilitation services. For healthcare practitioners in Romania, this reality underscores the particular importance of structured prevention and rehabilitation programs.

Advances made in recent decades have profoundly altered the natural course of cardiovascular diseases. Among the most important are:

- **early diagnosis**, using modern imaging methods (echocardiography, computed tomography coronary angiography, cardiac magnetic resonance imaging) and increasingly sensitive biomarkers;
- **interventional treatment**: primary coronary angioplasty in acute myocardial infarction, peripheral revascularization, percutaneous valve procedures, and thrombolysis or mechanical thrombectomy in acute stroke;
- **modern pharmacotherapy**: antithrombotic therapy, intensive lipid-lowering therapy, and treatments that improve prognosis in heart failure;
- **implantable devices**: pacemakers, implantable defibrillators, cardiac resynchronization therapy, and ventricular assist devices.

These advances have led to a significant increase in survival among patients with acute cardiovascular events. However, this development has resulted in an ever-growing population of chronic patients: survivors of a myocardial infarction or stroke, patients who have undergone revascularization, patients with heart failure, those with implantable devices, or those with atherosclerotic disease affecting multiple vascular territories. Added to this are an aging population and the rising prevalence of multimorbidity, so that today's cardiovascular patient is, on average, older, has more comorbidities, and faces a higher risk of recurrent events than a few decades ago.

A telling example is heart failure, whose prevalence continues to rise precisely because of improved survival after myocardial infarction and the aging of the population. Heart failure is one of the leading causes of hospitalization among people over 65 and is characterized by repeated readmissions,

reduced functional capacity, and poor quality of life. The same trend is observed in patients with atherosclerotic disease affecting multiple vascular territories and in those with implantable devices—groups that require a tailored rehabilitation approach.

These patients require structured rehabilitation programs designed to prevent recurrence of events, improve functional capacity and quality of life, reduce readmissions, and support family, social, and professional reintegration.

- **The Concept of Cardiovascular Rehabilitation**

Cardiovascular rehabilitation is defined by the European Society of Cardiology as a complex, multidisciplinary intervention that combines clinical assessment, exercise prescription, risk factor management, therapeutic education, and psychosocial support, with the aim of optimizing the physical and mental well-being of cardiac patients and reducing the risk of recurrent cardiovascular events.

This definition highlights a key aspect for the master's student's practice: cardiovascular rehabilitation is not limited to physical therapy or exercise training, but integrates secondary prevention as a structural—not optional—component. Without risk factor control and patient education, the benefits of physical training alone are limited in time. A patient who exercises correctly but continues to smoke, has uncontrolled blood pressure, or does not adhere to the prescribed treatment remains at increased risk of recurrent events.

A Brief History of the Concept

The approach to physical activity in cardiac patients has changed radically over the past few decades. Until the mid-20th century, strict bed rest for several weeks was recommended following a myocardial infarction, out of fear of complications such as myocardial rupture or arrhythmias. It was later demonstrated that prolonged immobilization has numerous negative effects: physical deconditioning, loss of muscle mass, venous thromboembolism, orthostatic hypotension, depression, and delayed return to work. In the 1960s and 1970s, the first programs for early mobilization and supervised physical training emerged, and in the following decades, these programs gradually expanded beyond the exercise component. This led to the current concept of comprehensive cardiovascular rehabilitation, which is patient-centered and integrated into the secondary prevention strategy.

Components of Cardiovascular Rehabilitation

According to documents from the European Association for Preventive Cardiology (EAPC), a comprehensive cardiovascular rehabilitation program includes the following components:

- initial clinical evaluation and risk stratification, including exercise testing;
- individualized aerobic and resistance exercise training, and counseling on daily physical activity;
- control of risk factors: blood pressure, lipid profile, diabetes, body weight, and smoking;
- nutritional counseling;
- optimization of pharmacological treatment and support for treatment adherence;
- therapeutic education for the patient and family regarding disease self-management;
- psychosocial assessment and support, including the identification of anxiety and depression;
- support for social and professional reintegration.

Phases of Cardiovascular Recovery

Recovery typically proceeds in three successive phases, ensuring continuity of care from the acute event through to long-term maintenance:

- **Phase I (in-hospital)**: early and progressive mobilization, initial assessment, basic education, and planning for the next steps;
- **Phase II (outpatient, supervised)**: a structured physical training program, typically lasting 8–12 weeks, combined with intensive secondary prevention;
- **Phase III (maintenance, long-term)**: maintaining the benefits achieved and a healthy lifestyle, with increased patient autonomy and periodic monitoring.

Who Should Undergo Cardiovascular Rehabilitation

Cardiovascular rehabilitation is a Class I recommendation in the ESC guidelines for patients following acute coronary syndrome or coronary revascularization, for patients with chronic coronary syndrome, and for those with chronic heart failure. The indications have gradually expanded to include other patient groups: those who have undergone cardiac surgery or percutaneous valve procedures, those with implantable devices , those who have undergone heart transplantation, those with peripheral arterial disease, as well as elderly and frail patients.

The Roles of Cardiovascular Rehabilitation

A well-structured rehabilitation program fulfills several roles simultaneously, extending far beyond the period immediately following the acute event:

- **direct therapeutic role**: physical training improves functional capacity, endothelial function, muscle metabolism, and, in some patients, ventricular remodeling;
- **secondary prevention role**: active management of risk factors and the development of sustainable healthy habits;
- **optimization of pharmacological treatment**: monitoring adherence, identifying adverse effects, and titrating treatment to the doses recommended by guidelines;
- **educational role**: the patient learns to understand their condition, recognize warning signs, and self-monitor their weight, blood pressure, and symptoms;
- **early identification of complications**: regular contact with the medical team allows for the early recognition of signs of decompensation, residual ischemia, or arrhythmias;
- **psychological support**: regaining confidence in one's ability to exercise and identifying patients with anxiety or depression who require specialized evaluation;
- **social and occupational reintegration**: objective recommendations regarding the resumption of work, driving, and daily activities.

The benefits of cardiovascular rehabilitation are well documented: reduced cardiovascular mortality, readmissions, and recurrent events, as well as improved exercise capacity, symptom relief, and quality of life. However, rehabilitation remains underutilized throughout Europe: only a fraction of eligible patients are referred to a program, and an even smaller proportion complete it. Barriers stem from the healthcare system (insufficient number of centers, lack of referrals from the attending physician), the patient (distance from the center, lack of motivation, comorbidities), and the misconception that rehabilitation is an optional step. Telerehabilitation and hybrid programs are current solutions for increasing access.

- **The Concept of Cardiovascular Prevention**

Cardiovascular prevention encompasses the range of interventions, at both the individual and population levels, aimed at eliminating or reducing the impact of cardiovascular diseases and associated disability. It is traditionally structured into four levels, each with specific objectives and intervention tools.

Table 1 . Levels of cardiovascular prevention: target population and objectives

Level of Prevention	Target Population	Main Objective
Primary prevention	General population, without existing risk factors	Preventing the emergence of risk factors (promoting a healthy lifestyle from a young age)
Primary prevention	People with risk factors but no manifest cardiovascular disease	Reducing the risk of a first cardiovascular event
Secondary prevention	Patients with already diagnosed cardiovascular disease	Preventing recurrence of events and slowing disease progression
Tertiary prevention	Patients with advanced disease or sequelae	Limiting complications, maintaining functionality and quality of life

Practical note: *Cardiovascular rehabilitation primarily focuses on secondary and tertiary prevention, but the educational component of the program also has an impact at the primary level by influencing the patient's family members and community.*

Cardiovascular Risk Factors—The Common Target of Prevention

Regardless of the level at which it is applied, cardiovascular prevention has risk factors as its common target. These are traditionally divided into two broad categories:

- **non-modifiable risk factors**: age, male gender, family history of premature cardiovascular disease, and genetic predisposition. Although they cannot be influenced, they are essential for estimating overall risk and determining the intensity of intervention;
- **modifiable risk factors**: high blood pressure, dyslipidemia, smoking, diabetes, obesity (especially abdominal obesity), physical inactivity, unhealthy diet, excessive alcohol consumption, and psychosocial stress.

Current guidelines also recognize a number of factors that modulate cardiovascular risk: chronic kidney disease, chronic systemic inflammation, elevated lipoprotein (a) levels, low socioeconomic status, air pollution, and certain conditions specific to women, such as hypertensive complications of pregnancy. Risk factors tend to be associated with one another and to potentiate each other, so that the overall risk for a patient with several moderately elevated factors may be higher than that of a patient with a single markedly elevated factor. For this reason, modern prevention is based on assessing overall risk and simultaneously managing all factors, rather than treating each one in isolation.

Primary Prevention

Aims to prevent the emergence of risk factors before they take hold. It targets the general population, starting in childhood, and is based primarily on public health policies: promoting healthy eating and physical activity in schools and communities, anti-smoking legislation, reducing the salt, sugar, and trans fat content in processed foods, and urban planning that encourages walking and cycling.

Primary Prevention

This approach targets individuals who already have risk factors but do not yet have overt cardiovascular disease, with the goal of preventing the first cardiovascular event. The first step is to assess overall cardiovascular risk, for example using the SCORE2 and SCORE2-OP scores (for individuals over 70 years of age), as recommended by the ESC prevention guidelines. Depending on the risk category, intervention includes lifestyle modifications (quitting smoking, healthy eating, regular physical activity, weight control) and, when indicated, pharmacological treatment of risk factors: antihypertensives, lipid-lowering agents, and treatment for diabetes.

Secondary Prevention

This is intended for patients with already diagnosed cardiovascular disease: following a myocardial infarction, stroke, or revascularization, as well as patients with peripheral arterial disease. The goal is to prevent recurrent events and slow the progression of the disease. By definition, these patients fall into the very high cardiovascular risk category, with strict therapeutic targets:

- intensive control of LDL cholesterol, blood pressure, and blood glucose;
- appropriate antithrombotic therapy;
- complete cessation of smoking;
- regular physical activity, a healthy diet, and weight control;
- long-term adherence to pharmacological treatment.

Cardiovascular rehabilitation is the primary organized tool for secondary prevention, as it provides the framework within which all these interventions can be implemented in a coordinated manner, monitored, and adjusted over time.

Tertiary Prevention

This is aimed at patients with advanced cardiovascular disease or sequelae: heart failure, severe ventricular dysfunction, post-stroke neurological sequelae, and amputations due to peripheral arterial disease. The goal is to limit complications and disability, maintain functional autonomy, and improve quality of life. At this level as well, cardiovascular rehabilitation plays a central role, especially for

complex patients, for whom the program must be tailored to the severity of the disease and associated comorbidities.

- **The Role of Prevention in the Rehabilitation Program**

Integrating prevention into cardiovascular rehabilitation is not a secondary element but rather the backbone of long-term intervention. Clinical studies have consistently demonstrated that rehabilitation programs combining physical exercise with active risk factor management reduce cardiovascular mortality and readmission rates by significant percentages, exceeding those achieved through physical exercise alone.

From the perspective of a practicing professional who will work in multidisciplinary teams, it is essential to remember that rehabilitation without prevention addresses the consequence (functional deficit), whereas rehabilitation with a preventive component addresses both the consequence and the cause (the progression of atherosclerosis, metabolic instability, and risk behaviors).

In practice, the preventive component is integrated into every stage of the program:

- **during the initial assessment**: identifying all risk factors, classifying the patient into a risk category, and establishing individual treatment goals;
- **during Phase II**: monitoring blood pressure and weight at each session, smoking cessation counseling, nutritional counseling, checking treatment adherence, and reporting to the attending physician any instances where targets are not met;
- **at the end of the program**: reassessing the risk profile, comparing it with baseline values, and establishing a concrete maintenance plan;
- **in Phase III**: maintaining the healthy behaviors acquired through self-monitoring, periodic check-ups, and, where possible, through community or telerehabilitation programs.

The period following an acute cardiovascular event represents a true "window of opportunity": the patient is, at this time, most receptive to lifestyle changes. The recovery program aims to transform this initial motivation—which is often short-lived—into lasting behaviors. Family involvement also plays an important role, as dietary changes, quitting smoking, or increasing physical activity are much easier to sustain when adopted by the entire family.

Practical note: *Every follow-up visit is also a preventive care visit: measuring blood pressure, discussing smoking, or reviewing treatment takes only a few minutes, but repeating these steps 2–3 times a week for several months has a significant cumulative impact on managing risk factors.*

- **International Guidelines and Recommendations**

Current cardiovascular rehabilitation practice is primarily guided by the European Society of Cardiology (ESC) recommendations on the prevention of cardiovascular disease in clinical practice and by the guidelines of the American Heart Association (AHA) and the American College of Cardiology (ACC). These documents establish specific treatment goals for each risk factor (target values for blood pressure, lipid profile, and blood glucose), as well as recommendations regarding the volume and intensity of physical activity.

The prevention guidelines are supplemented by ESC guidelines dedicated to each specific condition (acute and chronic coronary syndromes, heart failure, peripheral arterial disease, atrial fibrillation, hypertension, dyslipidemia, and diabetes mellitus), which specify the indications for cardiovascular rehabilitation for each patient category. The ESC guidelines on cardiac rehabilitation provide a unified framework for organizing programs, while the EAPC position papers detail practical aspects: program structure, initial assessment, exercise prescription, and recommendations for special populations.

The guidelines' recommendations are accompanied by a recommendation class (I, IIa, IIb, III) and a level of evidence (A, B, C), which allow practitioners to assess how robust each recommendation is. For cardiovascular rehabilitation, most key recommendations are Class I, meaning that the benefit is clearly demonstrated and that the intervention should be offered to all eligible patients.

With regard to physical activity, the ESC guidelines recommend that adults, including stable cardiovascular patients, at least 150–300 minutes per week of moderate-intensity aerobic activity or 75–150 minutes of vigorous-intensity activity, combined with strength training at least twice a week and a reduction in sedentary time. For cardiovascular patients, these general recommendations are tailored based on clinical evaluation and exercise testing.

The guidelines should not be viewed as rigid prescriptions, but rather as guidelines to be adapted to the individual patient, local resources, and the context of the national healthcare system. They are periodically revised as new scientific evidence emerges, so target values and recommendation classes may change from one edition to the next.

Practical Note: *It is recommended to consult the updated version of the ESC guidelines on cardiovascular prevention and cardiac rehabilitation, available on the society's official website, as target values and recommendation classes may be revised periodically.*

Summary: *Increased survival following acute cardiovascular events has led to a growing population of chronic, elderly, and complex patients with an increased risk of recurrence. Cardiovascular rehabilitation, defined as a complex multidisciplinary intervention, is the organized approach through which secondary and tertiary prevention is implemented in these patients. For master's students, understanding this framework is essential: physical training is only one component of a broader, h e process, whose ultimate goal is to reduce the risk of new events and preserve the patient's autonomy and quality of life.*

2. CARDIOVASCULAR RISK FACTORS—THE CENTRAL OBJECTIVE OF PREVENTION

Cardiovascular risk factors are biological, behavioral, or environmental characteristics associated with an increased likelihood of the onset or progression of cardiovascular disease. The concept emerged in the mid-20th century following major prospective epidemiological studies—the most well-known of which is the Framingham Study—which demonstrated that cardiovascular disease is not an inevitable consequence of aging, but rather the result of cumulative, lifelong exposure to factors that can largely be identified and controlled.

Risk factors are traditionally divided into nonmodifiable and modifiable factors, to which are added a number of additional or emerging factors whose role is increasingly well documented. Three general principles are essential for rehabilitation practice:

- **Risk factors are interrelated and reinforce one another**: the overall risk for a patient with several moderately elevated risk factors may be higher than that of a patient with a single markedly elevated risk factor;
- **Risk is cumulative over time**: prolonged exposure, even at moderately elevated levels, has a greater effect than brief exposure to high levels;
- **Intervention must be comprehensive**: modern prevention is based on assessing overall risk and simultaneously controlling all factors, not on treating each one in isolation.

For patients with already manifest cardiovascular disease who are enrolled in a rehabilitation program, formal risk assessment using scoring systems (SCORE2, SCORE2-OP) is no longer necessary: they fall directly into the very high-risk category. However, identifying each risk factor remains essential, as each one represents a specific target for intervention.

2.1. Non-modifiable risk factors

These factors cannot be influenced by therapeutic intervention or lifestyle changes, but identifying them is essential for the accurate stratification of overall cardiovascular risk and for determining the intensity of intervention on modifiable factors. A patient with multiple non-modifiable risk factors requires more rigorous control of the modifiable risk factors, precisely because the potential for risk reduction lies solely with these factors.

• Age

Cardiovascular risk increases progressively with advancing age, particularly after age 45 in men and age 55 in women, as a result of the accumulation over time of vascular structural and functional changes (arterial stiffness, endothelial dysfunction) and prolonged exposure to other risk factors. Age is, in fact, the strongest determinant of risk in all estimation models, including SCORE2.

Aging is also associated with changes that directly influence recovery: a decrease in maximum aerobic capacity, loss of muscle mass and strength (sarcopenia), an increased prevalence of comorbidities and polypharmacy, as well as a higher risk of frailty and falls. Advanced age, however, is not a contraindication for rehabilitation; on the contrary, older patients often achieve significant functional benefits that directly impact their independence.

Relevance to the rehabilitation program: assessment of frailty and fall risk, adjustment of training intensity and progression, and inclusion of balance and muscle strength exercises.

• Male

Men have an increased cardiovascular risk compared to premenopausal women, a difference attributed in part to the protective effect of estrogen on lipid profile and endothelial function. After the onset of menopause, women's cardiovascular risk increases progressively, approaching that of men of the same age.

Cardiovascular disease in women has several important characteristics: onset occurs, on average, about 7–10 years later than in men; symptoms are more frequently atypical (shortness of breath, fatigue, nausea, epigastric pain); and diagnosis and treatment are often delayed. In addition, women are underrepresented in both clinical trials and cardiovascular rehabilitation programs.

Current guidelines also recognize a number of **risk factors specific to women**, which should be actively sought during the medical history: preeclampsia and gestational hypertension, gestational diabetes, preterm birth, early menopause (before age 40), polycystic ovary syndrome, and

autoimmune diseases, which are more common in women. These factors can help identify women at high risk even before the classic risk factors appear.

Relevance to the rehabilitation program: actively screening for risk factors specific to women, recognizing atypical symptoms, and actively encouraging women's participation in rehabilitation programs.

• Family history of early-onset cardiovascular disease

The presence of an early cardiovascular event (myocardial infarction or sudden cardiac death) in a first-degree relative—before age 55 in men and age 65 in women—indicates an increased predisposition, often multifactorial, and warrants a more careful assessment of individual risk, even in the absence of other obvious risk factors.

Family history reflects both genetic factors and lifestyle habits common to the family (diet, smoking, physical inactivity). For this reason, identifying it in a patient enrolled in the rehabilitation program serves a dual purpose: it justifies stricter monitoring of the patient's risk factors and opens the possibility for primary prevention interventions among family members.

• Genetic predisposition

Certain genetically determined conditions, such as familial dyslipidemias (e.g., familial hypercholesterolemia), are associated with markedly elevated levels of LDL cholesterol as early as childhood and with a substantially increased risk of early coronary artery disease; for this reason, identifying them through family history and, when indicated, through genetic testing, has direct implications for the intensity of treatment.

Heterozygous familial hypercholesterolemia is one of the most common genetic disorders, with an estimated prevalence of approximately 1 in 300 people, but it remains largely undiagnosed. It should be suspected in any patient with very high LDL cholesterol (typically above 190 mg/dL in the absence of treatment), with early-onset coronary artery disease, or with a suggestive family history. Another condition with a predominantly genetic aetiology is **lipoprotein (a)**, discussed in the section on dyslipidemia.

2.2. Modifiable Risk Factors

These constitute the primary target of rehabilitation and prevention interventions. Unlike nonmodifiable risk factors, they can be actively addressed through pharmacological treatment, lifestyle modifications, and therapeutic education, which is why they represent the central objective of any cardiovascular rehabilitation program. International epidemiological studies have shown that a small number of modifiable risk factors account for the majority of the attributable risk of myocardial infarction and stroke worldwide.

• Hypertension

Hypertension is a major causal factor for both atherosclerotic cardiovascular disease and other cardiovascular conditions, particularly heart failure. It is also the most common cardiovascular risk factor and one of the leading causes of preventable death worldwide.

Elevated blood pressure levels, sustained over time, lead to vascular remodeling and left ventricular hypertrophy, which is why blood pressure control is a priority in any secondary prevention program. Uncontrolled hypertension is associated with coronary artery disease, heart failure, stroke, peripheral artery disease, chronic kidney disease, and atrial fibrillation.

The risk of death from coronary artery disease or stroke increases progressively as blood pressure rises. The benefit of lowering blood pressure depends on the initial cardiovascular risk and the magnitude of the reduction in systolic blood pressure, within the limits of treatment tolerability and safety. Meta-analyses of intervention studies show that a reduction of approximately 10 mmHg in systolic blood pressure is associated with a decrease of approximately 20% in major cardiovascular events.

The 2024 ESC Guidelines on Elevated Blood Pressure and Hypertension introduce three categories: **normal blood pressure** (below 120/70 mmHg), **elevated blood pressure** (120–139/70–89 mmHg), and **hypertension** (140/90 mmHg and above). For most treated patients, the recommended target for systolic blood pressure is **120–129 mmHg**, if well tolerated. When this target is not tolerated—for

example, in frail older adults or patients with orthostatic hypotension—the goal is to achieve the lowest reasonably achievable value.

Nonpharmacological measures have a proven effect on blood pressure: reducing salt intake, losing weight, engaging in regular physical activity, limiting alcohol consumption, and eating a diet rich in fruits and vegetables. Regular aerobic exercise can lower systolic blood pressure by a few mmHg, an effect comparable to that of an antihypertensive medication used as monotherapy.

Relevance to the rehabilitation program: measuring blood pressure before, during, and after each session; identifying an exaggerated blood pressure response to exercise and post-exercise hypotension; educating the patient on how to correctly measure blood pressure at home.

• Dyslipidemia

Elevated levels of LDL cholesterol, frequently associated with low HDL cholesterol and hypertriglyceridemia, directly promote the process of atherosclerosis. According to current evidence, lowering LDL cholesterol remains the intervention with the most robust proven impact on reducing the risk of recurrent coronary events.

- ***LDL Cholesterol and Atherogenic Lipoproteins***

The causal role of LDL cholesterol and other lipoproteins containing apolipoprotein B in the development of atherosclerosis is well established. Prolonged exposure to elevated LDL-C levels leads to a progressive increase in cardiovascular risk. Conversely, lowering LDL-C is associated with a reduction in cardiovascular risk, and the benefit is proportional to the magnitude of the LDL-C reduction.

The absolute benefit achieved by lowering LDL-C depends on both the absolute reduction in LDL-C and the patient's baseline cardiovascular risk. Therefore, the same reduction in LDL-cholesterol yields a greater absolute benefit in patients at high or very high risk than in those at low risk.

For patients with documented atherosclerotic cardiovascular disease classified as very high risk, the ESC/EAS guidelines recommend an LDL-cholesterol level **below 55 mg/dl** and a reduction of **at least 50%** from the baseline value. For patients who have experienced a second cardiovascular event within 2 years while on the maximum tolerated lipid-lowering therapy, a target level below 40 mg/dL may be considered. The treatment strategy is phased: high-intensity statin, combination with ezetimibe, and, if necessary, a PCSK9 inhibitor.

- ***Non-HDL Cholesterol and Apolipoprotein B***

Non-HDL cholesterol reflects the total amount of atherogenic lipoproteins and is calculated using the formula:

Non-HDL cholesterol = total cholesterol – HDL cholesterol.

Its association with cardiovascular risk is at least as strong as that of LDL-C, and non-HDL cholesterol is one of the parameters used in SCORE2 and SCORE2-OP. Apolipoprotein B directly reflects the number of atherogenic particles. Both parameters are useful as secondary targets, particularly in patients with elevated triglycerides, diabetes, or obesity, in whom calculated LDL-cholesterol may underestimate the actual risk.

- ***HDL cholesterol and triglycerides***

HDL cholesterol is inversely correlated with cardiovascular risk and contributes to risk estimation; however, pharmacologically increasing HDL-C has not, in and of itself, proven to be an effective strategy for reducing cardiovascular events. Hypertriglyceridemia, common in patients with obesity, diabetes, or alcohol consumption, is a marker of triglyceride-rich lipoproteins with atherogenic potential. A fasting level below 150 mg/dl is associated with a lower risk, while very high levels (above 880 mg/dl) increase the risk of acute pancreatitis.

- ***Lipoprotein (a)***

Lipoprotein (a) is an atherogenic and prothrombotic lipoprotein, the level of which is determined almost entirely by genetics and remains relatively constant throughout life. The 2025 update to the ESC/EAS guidelines recommends measuring it at least once in a lifetime for every adult; levels above 50 mg/dl (105 nmol/l) increase cardiovascular risk. There is currently no specific therapeutic target, and for patients with elevated Lp(a), stricter control of other risk factors is recommended.

Relevance to the rehabilitation program: checking the complete lipid profile at the initial assessment and at the end of the program; identifying patients who do not meet the target and reporting them to the attending physician; verifying adherence to lipid-lowering therapy; and recognizing statin-associated myalgia, which must be distinguished from post-exercise muscle soreness.

• Active smoking and secondhand smoke exposure

Smoking is one of the most important modifiable cardiovascular risk factors and one of the major causes of preventable mortality.

Smoking accelerates the atherosclerotic process, promotes thrombosis and endothelial dysfunction, and the associated cardiovascular risk decreases significantly as early as the first few months after quitting. Multiple mechanisms are involved: endothelial damage, oxidative stress, systemic inflammation, increased platelet aggregability and fibrinogen levels, vasoconstriction, decreased HDL cholesterol, and increased carboxyhemoglobin levels, which reduce oxygen-carrying capacity.

According to the guidelines, approximately half of all preventable deaths among smokers are caused by atherosclerotic cardiovascular disease. The relative risk associated with smoking is particularly high among young people; for smokers under 50, the cardiovascular risk may be approximately five times higher than in nonsmokers. Secondhand smoke is also associated with an increased cardiovascular risk, which is why assessment and counseling should be extended, when relevant, to family members as well.

Quitting smoking after a coronary event is associated with a significant reduction in mortality—on the order of one-third—making it one of the most effective secondary prevention interventions. In peripheral artery disease, smoking is the strongest risk factor, and continuing to smoke after revascularization significantly increases the risk of occlusion and amputation. Guidelines recommend complete cessation of smoking; reducing the number of cigarettes is not sufficient. Alternative products (e-cigarettes, heated tobacco) are not without cardiovascular risk and should not be recommended as a preventive measure.

Relevance to the rehabilitation program: assessing smoking status at each session, providing structured counseling (e.g., using the "5A" model), collaborating with the physician for pharmacological treatment of addiction (nicotine replacement therapy, varenicline, bupropion), and preventing relapses.

• Diabetes and insulin resistance

Both type 1 and type 2 diabetes are independent risk factors for atherosclerotic cardiovascular disease. Diabetes increases the risk of coronary artery disease and stroke, particularly through its metabolic effects on the vascular endothelium and its frequent association with other risk factors (dyslipidemia, hypertension, obesity), which further amplify cardiovascular risk. The guidelines indicate an approximately twofold increased risk of atherosclerotic cardiovascular disease, which varies depending on population characteristics and the degree of diabetes control.

Insulin resistance and prediabetes (impaired fasting glucose, impaired glucose tolerance) are, in turn, associated with an increased cardiovascular risk, even before the onset of diabetes. Diabetic patients frequently have diffuse atherosclerotic disease, involvement of multiple vascular territories, and **silent ischemia**, meaning that the absence of angina does not rule out myocardial ischemia.

Adequate glycemic control, combined with the avoidance of hypoglycemic episodes, is an essential goal of the rehabilitation program. The 2023 ESC Guidelines for Cardiovascular Disease in Patients with Diabetes generally recommend a glycated hemoglobin level **below 7%**, with individualization for the elderly and frail patients. For patients with type 2 diabetes and atherosclerotic cardiovascular disease, SGLT2 inhibitors and/or GLP-1 receptor agonists with demonstrated cardiovascular benefits are recommended, regardless of glycemic control.

Relevance to the rehabilitation program: checking blood glucose levels before a session in patients treated with insulin or sulfonylureas, preventing and recognizing hypoglycemia, inspecting the feet of patients with neuropathy, and monitoring ECG changes in the absence of symptoms.

• Obesity

Obesity contributes both directly and indirectly to an increased cardiovascular risk. Body mass index and waist circumference are associated with the risk of atherosclerotic cardiovascular disease and

type 2 diabetes. In the apparently healthy population, overall mortality is lowest around a BMI of 20–25 kg/m², although weight should be interpreted within the context of the individual's clinical presentation.

Excess weight, especially when distributed predominantly in the abdominal (visceral) region, is associated with insulin resistance, atherogenic dyslipidemia, and hypertension, constituting an independent risk factor for cardiovascular disease. Visceral adipose tissue is an active endocrine organ that releases proinflammatory cytokines and sustains low-grade systemic inflammation, with a direct e e effect on atherosclerosis. Obesity is also associated with atrial fibrillation, heart failure with preserved ejection fraction, and obstructive sleep apnea.

Waist circumference is a better indicator of visceral fat than BMI: values above 94 cm in men and 80 cm in women indicate an increased risk, while values above 102 cm and 88 cm, respectively, indicate a high risk. A weight loss of 5–10% of initial body weight already improves blood pressure, lipid profile, and glycemic control. In older patients, **sarcopenic obesity**—in which excess fat coexists with reduced muscle mass—should also be considered.

Relevance to the rehabilitation program: measuring weight and waist circumference, combining aerobic and resistance training to preserve muscle mass, providing nutritional counseling, and adapting exercises to reduce joint stress.

2.3. Other Modifiable and Emerging Risk Factors

In addition to the classic risk factors presented above, current literature recognizes a number of additional factors with an increasingly well-documented role in cardiovascular risk, which are relevant for the comprehensive assessment of patients in a rehabilitation program.

• Sedentary lifestyle and low levels of physical activity

A lack of regular physical activity is independently associated with an increased cardiovascular risk, even in the absence of other risk factors, due to its negative effects on the metabolic profile, endothelial function, and cardiorespiratory fitness. From this perspective, the physical exercise component of the rehabilitation program serves both as a treatment and as a preventive measure.

Low cardiorespiratory fitness is one of the strongest predictors of mortality, and any increase in exercise capacity, even a modest one, is associated with a reduction in risk. The ESC guidelines recommend at least 150–300 minutes per week of moderate-intensity aerobic activity or 75–150 minutes of vigorous-intensity activity, combined with strength training at least twice a week. In addition to a lack of exercise, **sedentary time** (prolonged sitting) is an independent risk factor, which is why patients should be encouraged to frequently break up long periods of inactivity.

• Unhealthy diet

High intake of sodium, saturated fats, and refined sugars contributes to elevated blood pressure, dyslipidemia, and weight gain. Correcting these dietary habits is a cross-cutting goal that simultaneously addresses multiple risk factors.

The ESC Prevention Guidelines recommend a Mediterranean-style diet, rich in vegetables, fruits, whole grains, legumes, fish, nuts, and olive oil, with a reduction in red and processed meats, ultra-processed foods, and sweetened beverages. Specific recommendations include limiting salt intake to less than 5 g per day and saturated fat to less than 10% of total energy intake, replacing them with unsaturated fats.

• Excessive alcohol consumption

Excessive and chronic alcohol consumption is associated with high blood pressure, arrhythmias (including atrial fibrillation), and toxic cardiomyopathy; therefore, limiting or, where appropriate, eliminating alcohol consumption should be discussed on an individual basis with each patient. The ESC Prevention Guidelines recommend limiting alcohol consumption to a maximum of 100 g per week. The notion of a cardioprotective effect of moderate alcohol consumption is increasingly being called into question by recent data, and alcohol consumption should not be recommended as a preventive measure.

• Chronic stress, anxiety, and depression

Chronic psychological stress activates neuroendocrine mechanisms (increased cortisol and sympathetic tone) that promote hypertension, endothelial dysfunction, and risky behaviors (smoking,

physical inactivity, poor diet). Anxiety and depression, which are common following an acute cardiovascular event, are further associated with poor treatment adherence and a more guarded prognosis. Simple screening using standardized questionnaires allows for the identification of patients who require specialized psychological or psychiatric evaluation.

• Poor sleep quality and obstructive sleep apnea

Insufficient sleep duration or poor sleep quality, as well as untreated obstructive sleep apnea, are associated with hypertension, arrhythmias, and an increased risk of cardiovascular events through mechanisms related to intermittent hypoxia and nocturnal sympathetic activation. In adults, an optimal sleep duration of approximately 7–9 hours per night is considered . Sleep apnea should be suspected in patients who snore, have breathing pauses observed by a partner, experience daytime sleepiness, are obese, or have resistant hypertension. Screening for sleep disorders should be included in the initial evaluation of patients who are candidates for cardiovascular rehabilitation.

• Low-grade chronic inflammation

A chronic inflammatory state, clinically evidenced by elevated levels of high-sensitivity C-reactive protein, contributes to atherosclerotic plaque instability and is independently associated with the risk of coronary events, beyond lipid profile values. The concept of "residual inflammatory risk" describes patients who, despite having LDL cholesterol at target levels, continue to exhibit elevated inflammatory markers. Chronic inflammatory diseases (rheumatoid arthritis, psoriasis, systemic lupus erythematosus) are also associated with an increased cardiovascular risk. Regular physical activity, weight loss, and quitting smoking reduce systemic inflammation.

• Atrial fibrillation and other chronic arrhythmias

Atrial fibrillation significantly increases the risk of embolic stroke and is frequently associated with heart failure. Its presence requires, as part of the rehabilitation program, extra attention to anticoagulation and to adjusting the intensity of physical exertion. Due to the irregular heart rate, exercise intensity is best gauged using the Borg scale. Classic cardiovascular risk factors (hypertension, obesity, sleep apnea, alcohol consumption) are also risk factors for atrial fibrillation, and controlling them reduces the burden of the arrhythmia.

• Chronic kidney disease

Declining kidney function is associated with accelerated atherosclerosis and a substantially increased cardiovascular risk; indeed, kidney function is increasingly being incorporated into current models for estimating overall risk. The risk increases both as the glomerular filtration rate (GFR) decreases and as albuminuria increases. Severe chronic kidney disease (GFR below 30 mL/min/1.73 m^2) places the patient in the very high-risk category. In these patients, fluid and electrolyte balance, anemia, and medication dosing must be closely monitored.

• Hyperuricemia

Elevated uric acid levels are associated with hypertension, metabolic syndrome, and endothelial dysfunction, and are considered an additional risk marker, although its direct causal role remains partially debated in the literature.

• Air pollution

Chronic exposure to fine particulate matter (PM2.5) and other air pollutants is associated with an increased risk of acute cardiovascular events through mechanisms involving systemic inflammation and endothelial dysfunction, and is a recognized risk factor at the population level. At the individual level, patients with cardiovascular disease may be advised to avoid intense outdoor physical activity on days with high pollution levels or near heavy traffic.

• Socioeconomic Factors

Low educational attainment, low income, and limited access to medical services are associated with a higher prevalence of classic risk factors and lower adherence to prevention programs; therefore, assessing a patient's socioeconomic context is useful for tailoring interventions. These patients also often have the least access to rehabilitation programs, even though they benefit from them just as much.

• Social isolation
The lack of a social support network is independently associated with a poorer cardiovascular prognosis, both through psychological effects and through reduced adherence to treatment recommendations and the rehabilitation program. From this perspective, group rehabilitation programs can also serve as a source of social support.
• Shift work and disruption of the circadian rhythm
Shift work, particularly night shifts, is associated with circadian rhythm disruption, unhealthy eating and sleeping habits, and a slightly increased cardiovascular risk, documented especially with prolonged, long-term exposure.
• Use of psychoactive substances
The use of stimulant substances (cocaine, amphetamines) is associated with an increased risk of arrhythmias, acute coronary syndrome, and cardiomyopathy; for this reason, a history of use should be actively explored during the initial medical history, even if the patient does not mention it spontaneously.
Practical note: *Although some of these factors do not yet have standardized therapeutic targets in current clinical guidelines, their inclusion in the initial assessment provides a more complete picture of individual risk and can guide personalized interventions, complementary to standard ones.*

2.4. Therapeutic Targets for Major Risk Factors in Secondary Prevention

For patients with documented atherosclerotic cardiovascular disease who are enrolled in a rehabilitation program, the ESC guidelines establish specific targets for the major risk factors. These are summarized in the table below and should be assessed at the initial evaluation and at the end of the program.

Table 2 . Therapeutic targets for the main risk factors in secondary prevention

Risk factor	Recommended Target
Smoking	Complete cessation, including avoidance of secondhand smoke
Blood pressure	Systolic 120–129 mmHg and diastolic 70–79 mmHg, if well tolerated; for patients who cannot tolerate these levels, as low as reasonably possible
LDL cholesterol	Below 55 mg/dl and a reduction of at least 50% from baseline; a level below 40 mg/dl may be considered after a second event within 2 years
Non-HDL cholesterol / ApoB	Below 85 mg/dl / below 65 mg/dl (secondary targets)
Diabetes	HbA1c below 7%, individualized; SGLT2 inhibitors and/or GLP-1 agonists with cardiovascular benefits in patients with type 2 diabetes
Body weight	BMI 20–25 kg/m²; waist circumference below 94 cm in men and below 80 cm in women; for overweight individuals, a 5–10% weight loss as a primary goal
Physical activity	150–300 min/week of moderate-intensity activity or 75–150 min of vigorous-intensity activity, plus strength training at least twice a week
Diet	Mediterranean diet; salt intake below 5 g/day; saturated fat below 10% of total energy intake
Alcohol	Maximum 100 g per week

Practical Implications for the Rehabilitation Program
Understanding risk factors is not merely of theoretical value; it directly informs the work in the rehabilitation unit:

- **during the initial assessment**, all risk factors—both classic and emerging—are identified and documented, and a specific target is set for each;

- **Throughout the program**, measurable factors (blood pressure, weight, waist circumference, blood glucose in diabetic patients) are monitored periodically, and smoking status and treatment adherence are checked at every visit;
- **Patient education** aims to help patients understand the link between each risk factor and their condition, as well as to develop self-monitoring skills;
- **At the end of the program**, the risk profile is reassessed and compared with baseline values, and for factors that have not reached the target, a concrete plan is established and communicated to the treating physician and the family doctor;
- **Family involvement** allows the intervention to be extended to family members, who often share the same lifestyle habits.

Summary: *Cardiovascular risk factors act cumulatively and reinforce one another. Non-modifiable factors (age, sex, family history, genetic predisposition) define the environment in which the disease develops and necessitate more rigorous control of modifiable factors. Hypertension, dyslipidemia, smoking, diabetes mellitus, and obesity remain the primary targets of secondary prevention, with clearly defined target values in the ESC guidelines. Additional and emerging factors complete the picture of individual risk. For the rehabilitation team, each risk factor represents a specific target for intervention, and their simultaneous management is essential for the program's benefits to be sustained in the long term.*

3. ASSESSMENT AND STRATIFICATION OF OVERALL CARDIOVASCULAR RISK

3.1.The Concept of Overall Cardiovascular Risk

Modern preventive assessment should not be limited to simply noting that a patient has "high cholesterol," "high blood pressure," or "smokes." The therapeutic decision must be based on the patient's overall probability of developing a cardiovascular event.

This concept is based on the fact that the absolute benefit of an intervention is directly related to the initial cardiovascular risk. Two individuals with the same LDL-C level may require different treatment strategies if their overall cardiovascular risk differs. For example, an LDL-cholesterol level of 130 mg/dl has a completely different significance in a 45-year-old, non-smoking woman with normal blood pressure compared to a 60-year-old, smoking man with hypertension: although the lipid level is the same, the overall risk—and, consequently, the absolute benefit of treatment—differs considerably.

Overall cardiovascular risk represents the probability that a person will experience a major cardiovascular event (fatal or non-fatal) within a defined time frame—typically 10 years—as a result of the combined effect of all present risk factors, not a single isolated factor. This approach is based on the fundamental clinical observation that the effect of risk factors is multiplicative, not merely additive: a patient with multiple moderate risk factors may have a higher overall risk than a patient with a single, severe risk factor in isolation.

For this reason, modern therapeutic decisions—the intensity of lipid-lowering therapy, the threshold for initiating antihypertensive treatment, and the goals of the rehabilitation program—are no longer based on the isolated assessment of each parameter, but rather on classifying the patient into an overall risk category, determined using a validated calculation tool.

Absolute Risk and Relative Risk

When assessing and communicating risk, it is important to distinguish between two concepts:

- **absolute risk** represents the actual probability that a person will experience a cardiovascular event within a specific time frame (for example, 8% over the next 10 years). Therapeutic decisions are based on this;
- **relative risk** compares a person's risk to that of a person of the same age and sex but without risk factors. A young smoker with high blood pressure may have a low absolute 10-year risk, but a relative risk several times higher than that of a young person without risk factors.

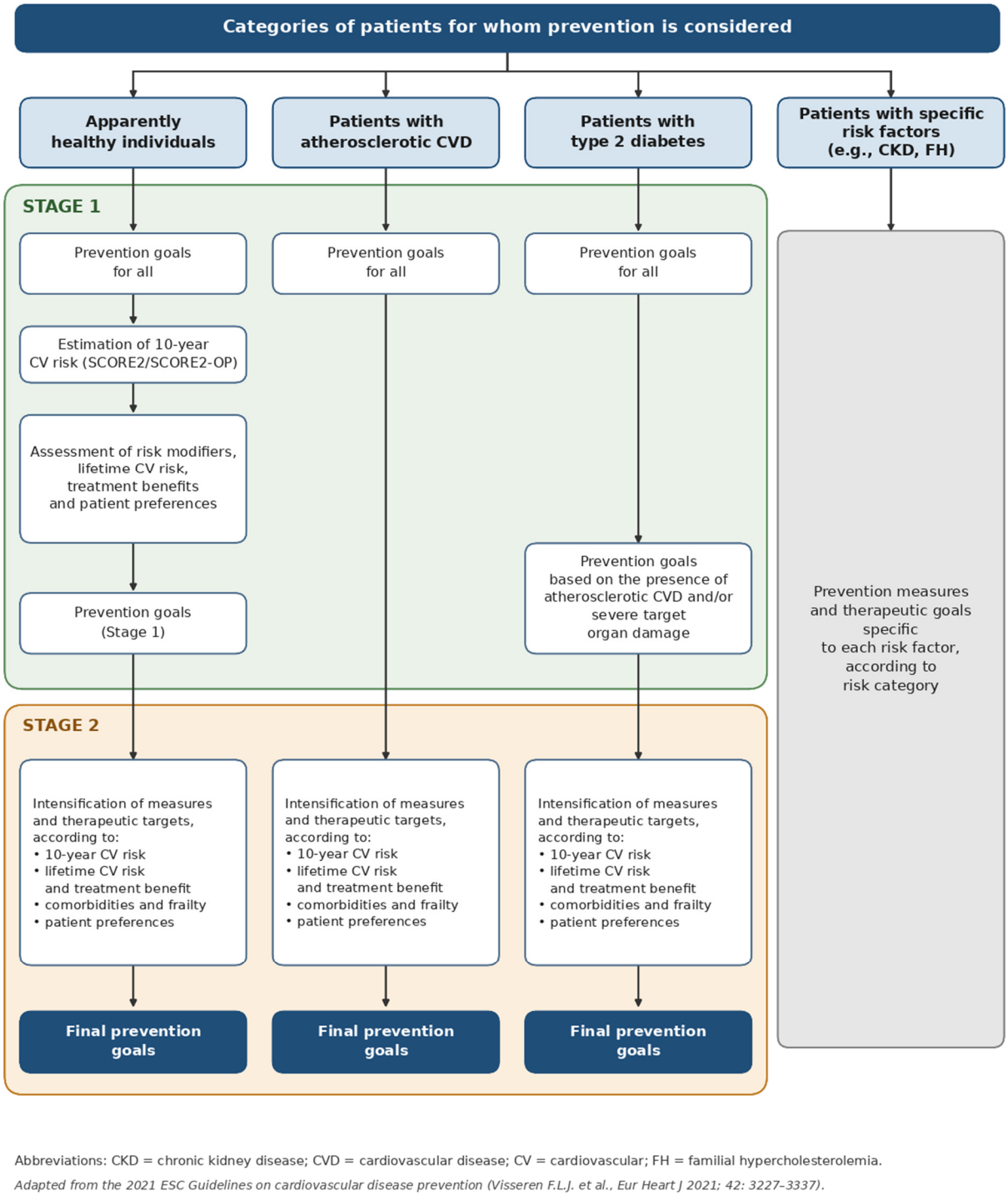
Absolute risk depends largely on age, so that in young people it may be low even in the presence of significant risk factors. For this reason, in young people, relative risk, lifetime risk, and the concept of "vascular age" are useful complementary tools for motivating the patient.

Patient Categories Requiring Different Approaches

The ESC prevention guidelines define four major categories of patients who require different approaches to risk assessment:

- apparently healthy individuals;
- patients with documented atherosclerotic cardiovascular disease;
- patients with diabetes mellitus;
- patients with conditions that in themselves confer an increased risk, such as chronic kidney disease or familial hypercholesterolemia.

Apparently healthy individuals are defined, in this context, by the absence of documented atherosclerotic cardiovascular disease, diabetes, and severe comorbidities. Risk is estimated using calculation scores only for this category; for the other categories, risk is determined based on direct clinical criteria.



Abbreviations: CKD = chronic kidney disease; CVD = cardiovascular disease; CV = cardiovascular; FH = familial hypercholesterolemia.

Adapted from the 2021 ESC Guidelines on cardiovascular disease prevention (Visseren F.L.J. et al., Eur Heart J 2021; 42: 3227–3337).

Figure 1. Categories of patients for whom prevention is considered

3.2. Cardiovascular Risk Assessment

Risk assessment is not performed by analyzing each factor in isolation, but rather through tools for calculating overall risk, which estimate the probability of a major cardiovascular event within a defined time frame. Currently, European guidelines recommend the use of the SCORE2 algorithm (and SCORE2-OP for older adults), which incorporates age, sex, smoking status, systolic blood pressure, and non-HDL cholesterol.

From SCORE to SCORE2

The first risk assessment tools were developed based on the Framingham Study in the United States. Because these tools overestimated risk in low-risk European populations and underestimated it in high-risk populations, the European Society of Cardiology introduced the **SCORE** (Systematic

COronary Risk Evaluation) system in 2003, calibrated for European cohorts. However, SCORE estimated only the 10-year risk of cardiovascular **death**, thereby underestimating the total burden of the disease, given that modern treatments have reduced mortality but not the incidence of nonfatal events.

In 2021, with the release of the new ESC prevention guidelines, SCORE was replaced by **SCORE2** and **SCORE2-OP**. The main changes are:

- estimation of the combined risk of **fatal and non-fatal** events (myocardial infarction, stroke), which more accurately reflects the actual burden of disease;
- the use **of non-HDL cholesterol** instead of total cholesterol, for a better assessment of atherogenic lipoproteins;
- **recalibration** using contemporary data for four European regions with different risk levels;
- the introduction of a model specifically for people aged **70 and older** (SCORE2-OP), which takes into account the competing risks of death from other causes, which are common among the elderly.

Target Population for SCORE2/SCORE2-OP Assessment

The SCORE2 and SCORE2-OP algorithms are intended to estimate risk in apparently healthy individuals with no documented atherosclerotic cardiovascular disease, no diabetes mellitus, no chronic kidney disease, and no familial hypercholesterolemia. They are applied, depending on age, as follows:

- **SCORE2** — individuals aged 40 to 69;
- **SCORE2-OP** ("Older Persons") — individuals aged 70 or older.

Patients who already have documented cardiovascular disease, diabetes mellitus, moderate-to-severe chronic kidney disease, or familial hypercholesterolemia do not require a SCORE2 calculation, as they are directly classified, based on clinical criteria, into the high- or very-high-risk category. For patients with type 2 diabetes without atherosclerotic cardiovascular disease and without severe target organ damage, the 2023 ESC Diabetes Guidelines have introduced a dedicated model, **SCORE2-Diabetes**, which incorporates diabetes-specific parameters (age at diagnosis, HbA1c, glomerular filtration rate).

Practical note: *This distinction is essential: SCORE2 stratifies risk in the general population, whereas in patients with established cardiovascular disease—the core population of rehabilitation programs—classification into the very high-risk category is, as a rule, automatic.*

Risk Assessment Using SCORE2 and SCORE2-OP

SCORE2 and SCORE2-OP estimate the 10-year combined risk of fatal and non-fatal cardiovascular events (myocardial infarction, stroke) by incorporating age, sex, smoking status, systolic blood pressure, and non-HDL cholesterol. The use of non-HDL cholesterol allows for the consideration of all atherogenic lipoproteins, not just LDL-C.

Calibration by risk regions. Romania's position

The models are calibrated by geographic regions with different levels of cardiovascular risk (regions with low, moderate, high, and very high population-level risk), thereby adapting them to the local epidemiological context. Countries were classified into these regions based on standardized cardiovascular mortality rates reported by the World Health Organization.

Romania belongs to the very high cardiovascular risk region, along with other countries in Eastern Europe, the Balkans, and the eastern and southern Mediterranean basin. Consequently, to estimate risk in patients in Romania, the charts and calculators calibrated for the very-high-risk region must be used. Using the wrong calibration—for example, that for low-risk countries—would lead to a significant underestimation of risk and, consequently, to undertreatment of the patient.

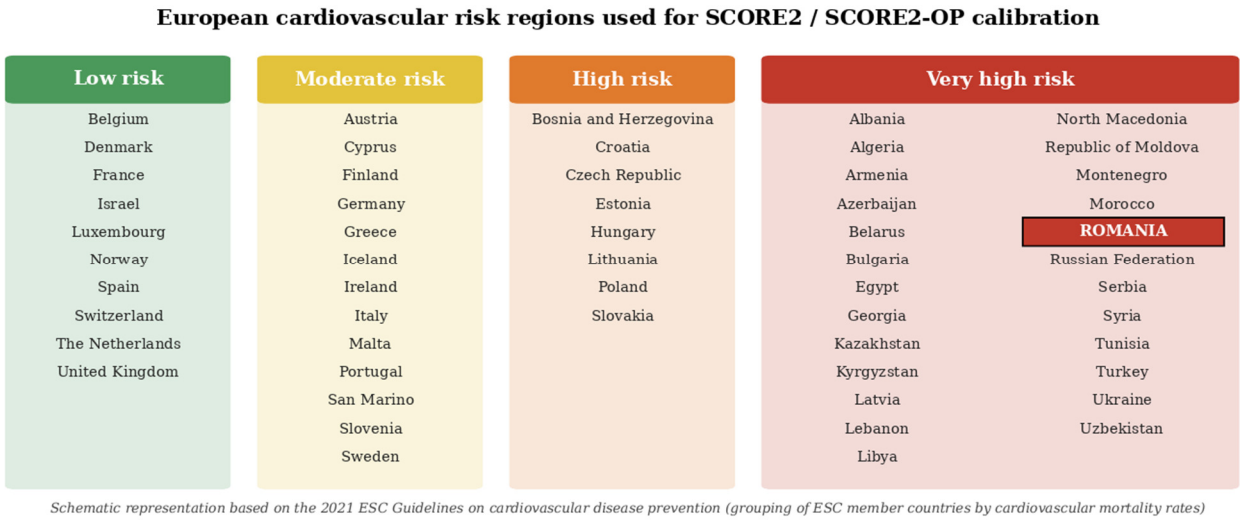


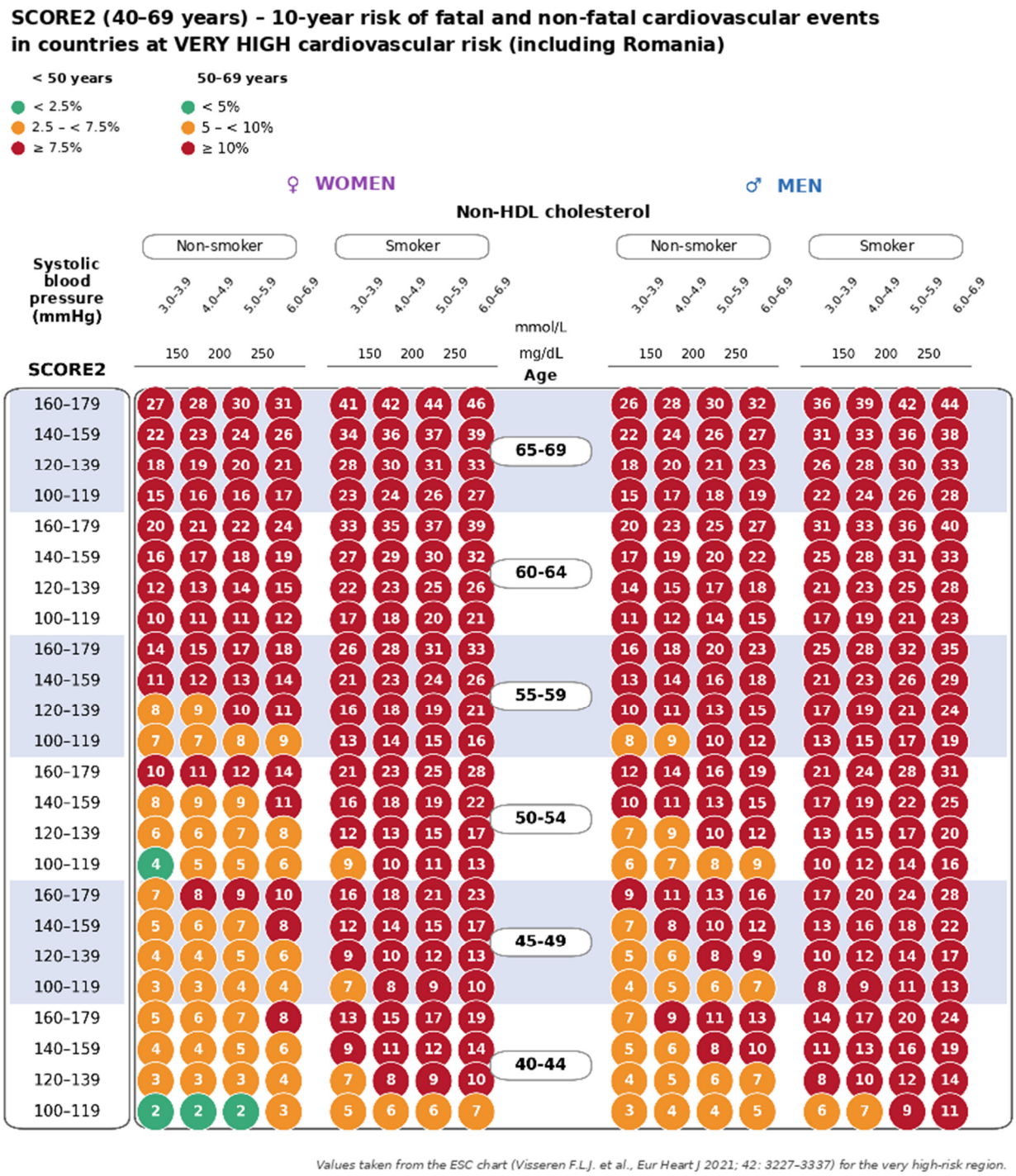
Figure 2. European cardiovascular risk regions used for SCORE2/SCORE2-OP calibration; Romania is in the very-high-risk region (schematic representation based on the 2021 ESC guidelines for cardiovascular prevention).

Using the SCORE2 and SCORE2-OP Charts

The SCORE2 and SCORE2-OP charts are organized by sex, smoking status, and age group. In each chart, the rows correspond to systolic blood pressure values, and the columns to non-HDL cholesterol values. The chart is read as follows:

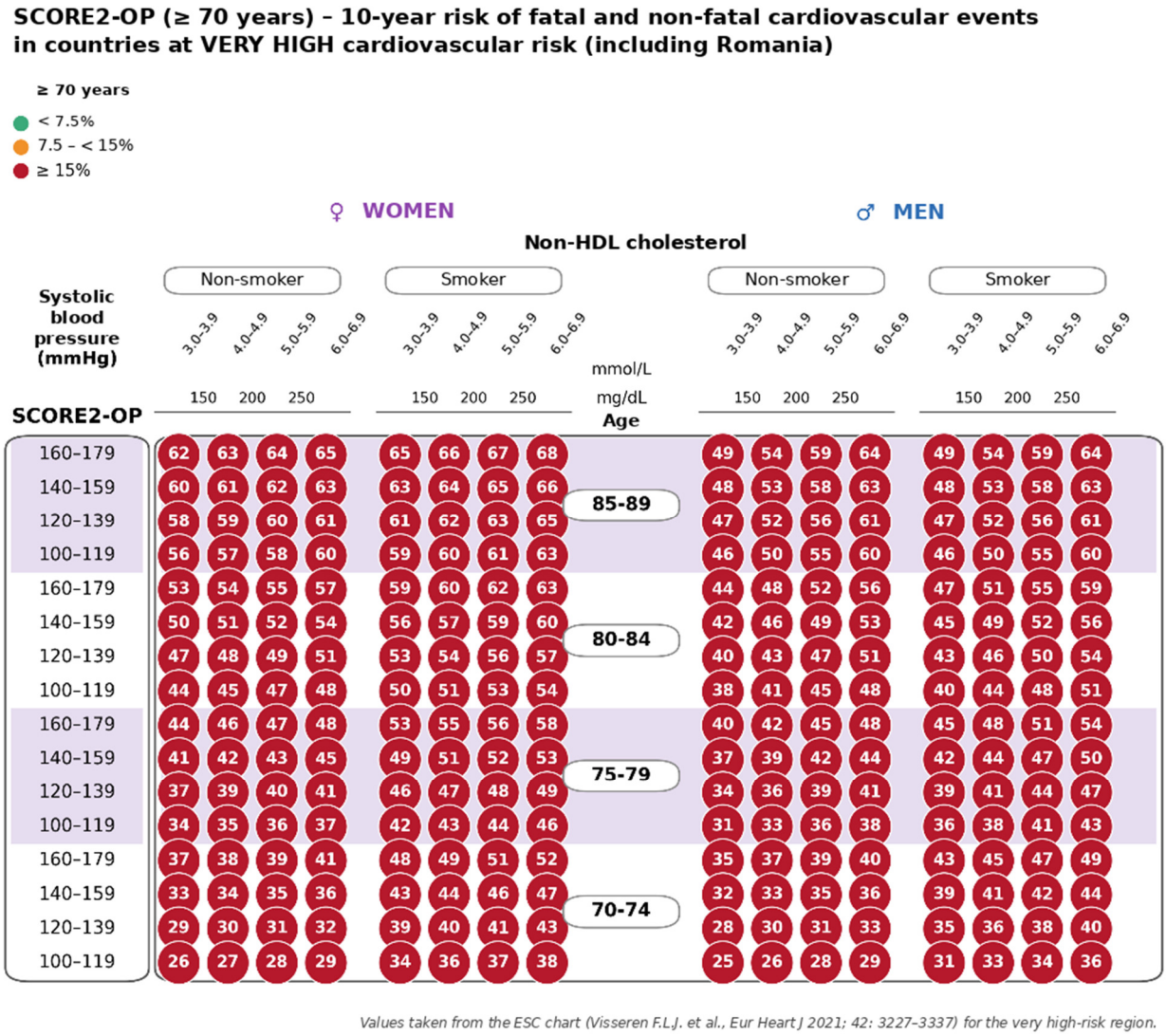
1. Select the chart corresponding to the risk region (for Romania, the very high-risk region) and the age group (SCORE2 or SCORE2-OP);
2. Identify the table corresponding to the patient's sex and smoking status;
3. Locate the cell at the intersection of the age group, systolic blood pressure, and non-HDL cholesterol level;
4. The value in the box represents the estimated 10-year risk (%) of a fatal or non-fatal cardiovascular event, and the color indicates the risk category.

In addition to the printed charts, risk can be calculated more accurately using electronic calculators, such as the free ESC CVD Risk Calculation app, which uses exact parameter values rather than the ranges shown on the chart.



Values taken from the ESC chart (Visseren F.L.J. et al., Eur Heart J 2021; 42: 3227–3337) for the very high-risk region.

Figure 3. SCORE2 chart (ages 40–69) for countries with very high cardiovascular risk



Values taken from the ESC chart (Visseren F.L.J. et al., Eur Heart J 2021; 42: 3227–3337) for the very high-risk region.

Figure 4. SCORE2-OP chart (≥ 70 years) for countries with very high cardiovascular risk

Risk thresholds by age

The risk thresholds defining the low-moderate, high, and very high categories differ by age group:

Table3 . SCORE2/SCORE2-OP risk thresholds by age group

Age group	Low-moderate risk	High risk	Very high risk
< 50 years	< 2.5%	2.5% – < 7.5%	≥ 7.5%
50–69 years	< 5%	5% – < 10%	≥ 10%
≥ 70 years (SCORE2-OP)	< 7.5%	7.5% – < 15%	≥ 15%

Practical note: *The percentage values represent the estimated 10-year risk of fatal and non-fatal cardiovascular events, according to the SCORE2/SCORE2-OP model. The master's student should note that these thresholds are specific to each age group and cannot be directly compared across different age categories.*

The lower thresholds for younger individuals reflect the fact that, for the same percentage value, a young person faces a much longer period of exposure to risk factors, and the long-term benefit of early intervention is greater. It should be noted that the 2025 update of the ESC/EAS guidelines for the management of dyslipidemia uses single, age-independent SCORE2 thresholds for classification into risk categories that determine lipid targets (below 2%—low risk, 2–<10% – moderate, 10–<20%

– high, ≥ 20% – very high). Clinicians must be familiar with the guidelines to which a score refers when interpreting it.

Limitations of SCORE2

Like any statistical model, SCORE2 has a number of limitations that must be understood for a correct interpretation:

- it does not apply to people under 40 years of age, for whom the 10-year absolute risk is almost always low;
- it does not include all relevant risk factors: family history, obesity, physical inactivity, socioeconomic status, or psychosocial factors are not incorporated into the calculation;
- it estimates risk only over a 10-year period, which may underestimate the importance of risk factors in younger individuals;
- it is a population-based estimate applied to an individual, so the result must be interpreted within the clinical context of each patient.

Factors That Can Modify the Risk Estimate

The result obtained using SCORE2 can be adjusted, either upward or downward, depending on the presence of factors not included in the model but which influence actual risk. The ESC prevention guidelines mention, among other things:

- **psychosocial stress** and psychiatric disorders (depression, anxiety, psychotic disorders);
- low **socioeconomic status** and membership in certain high-risk ethnic groups;
- **frailty**, which can influence both the risk and the benefit-risk ratio of treatment;
- **family history** of early-onset cardiovascular disease;
- **imaging**: the coronary calcium score determined by computed tomography or the presence of carotid or femoral plaques on ultrasound can reclassify risk, especially in individuals near the decision thresholds;
- elevated **lipoprotein (a)**, recognized by the 2025 update of the ESC/EAS guidelines as a factor that can reclassify the patient into a higher risk category.

There are also conditions associated with an increased cardiovascular risk that must be taken into account: chronic inflammatory diseases (rheumatoid arthritis, psoriasis, systemic lupus erythematosus), HIV infection, cancer and its treatments, COPD, obstructive sleep apnea, metabolic fatty liver disease, migraine with aura, as well as conditions specific to women (preeclampsia, gestational hypertension, early menopause, polycystic ovary syndrome).

Long-term cardiovascular risk

Assessing risk exclusively over a 10-year period may be insufficient, particularly in younger individuals. The guideline explicitly introduces the concept of long-term cardiovascular risk and the long-term benefits of treatment.

Long-term risk can be estimated clinically or using dedicated models. For apparently healthy individuals, the guidelines mention the **LIFE-CVD** model, which can help communicate the risk and benefit of treatment. The guidelines conceptually define long-term risk as the age at which the cumulative probability of a cardiovascular event or death reaches 50%, and the benefit of treatment as the difference between this estimated age in the absence of and in the presence of intervention.

The benefit of the intervention can be intuitively expressed in terms of the number of years of life free from cardiovascular disease gained by quitting smoking, lowering LDL cholesterol, or reducing blood pressure. This method of presentation can be much easier for the patient to understand than simply communicating a percentage risk. A related concept is that of **vascular age** (or "risk age"): the age of a person without risk factors who would have the same risk as the patient being evaluated. The statement "Your heart and blood vessels are the age of a 65-year-old, even though you are 50" is often more compelling than a percentage.

And for patients with established cardiovascular disease, there are dedicated models for estimating the risk of recurrent events (e.g., the SMART model), which show that risk can vary considerably even within the very-high-risk category and can help estimate the benefit of intensifying treatment.

3.3. Cardiovascular Risk Stratification

In addition to the risk calculated using SCORE2/SCORE2-OP, the ESC guidelines on cardiovascular prevention and dyslipidemia management define direct clinical criteria for classification into risk categories, applicable in particular to patients with established cardiovascular disease or other conditions associated with an inherently increased risk — a category that includes the majority of patients enrolled in a cardiovascular rehabilitation program.

Table 4 . Cardiovascular Risk Categories—Clinical Classification Criteria

Risk category	Clinical classification criteria
Low-to-moderate risk	SCORE2/SCORE2-OP in the low-to-moderate range for the respective age, in the absence of documented cardiovascular disease, diabetes, chronic kidney disease, or familial hypercholesterolemia.
High risk	SCORE2/SCORE2-OP classified in the high category; or a single, severe risk factor (total cholesterol > 310 mg/dl, LDL cholesterol > 190 mg/dl, blood pressure ≥ 180/110 mmHg); familial hypercholesterolemia without other major risk factors; diabetes mellitus without target organ damage, with a duration of ≥ 10 years or with an associated risk factor; moderate chronic kidney disease (estimated GFR 30–59 ml/min/1.73 m²).
Very high risk	Clinically or imaging-confirmed atherosclerotic cardiovascular disease (myocardial infarction, acute coronary syndrome, coronary or peripheral revascularization, ischemic stroke, transient ischemic attack, peripheral arterial disease); diabetes mellitus with target organ damage or with at least three associated major risk factors; severe chronic kidney disease (estimated GFR < 30 mL/min/1.73 m²); familial hypercholesterolemia associated with cardiovascular disease or another major risk factor; SCORE2/SCORE2-OP classified as "very high."

"Imaging-confirmed atherosclerotic cardiovascular disease" refers to the presence of significant atherosclerotic plaques on coronary angiography, computed tomography coronary angiography, or carotid ultrasound, even in the absence of a clinical event. Target organ damage in diabetes includes microalbuminuria, retinopathy, and neuropathy.

Practical note: *The vast majority of patients admitted to a cardiovascular rehabilitation program—who, by definition, are individuals with already documented cardiovascular disease—fall directly into the very high-risk category based on clinical criteria, without the need for a SCORE2 calculation. This classification has direct therapeutic implications: stricter targets for LDL cholesterol and blood pressure, more frequent monitoring, and a more structured rehabilitation program, as shown in the summary table below.*

Table 5 . Interpretation of Risk Categories and Implications for the Rehabilitation Program

Risk category	Guidance on Interpretation	Implications for the rehabilitation program
Low-to-moderate risk	Estimated risk below the thresholds for intensive intervention	Standard program, with an emphasis on maintaining a healthy lifestyle and on primary prevention of risk factors
High risk	Presence of one severe major risk factor or multiple associated risk factors	Intensified risk factor control, stricter treatment goals, more frequent monitoring
Very high risk	Documented cardiovascular disease, diabetes with target organ damage	Structured rehabilitation program covering all three phases, strict therapeutic goals (LDL cholesterol, blood pressure), close monitoring, and periodic reassessment

It should be emphasized that, even within the very high-risk category, patients are not homogeneous. A patient with recurrent events, involvement in multiple vascular territories (polyvascular disease), diabetes, and chronic kidney disease has a considerably higher risk than a patient with a single coronary event who has undergone complete revascularization and has no other risk factors. The guidelines acknowledge this situation by setting even stricter treatment targets for certain subgroups; for example, an LDL cholesterol level below 40 mg/dl for a patient who has experienced a second vascular event within two years.

3.4. Risk Communication and Shared Decision-Making Between Physician and Patient

Simply calculating a risk score is not the end goal of cardiovascular assessment. The result must be explained to the patient in an accessible manner and integrated into a shared decision-making process between physician and patient, which supports both understanding and adherence to the proposed interventions.

The ESC guidelines explicitly recommend (Class I recommendation)—an informed discussion regarding cardiovascular risk and the potential benefits of treatment, tailored to each patient's needs and level of understanding. This discussion should incorporate both short-term and long-term risks, the anticipated benefits of interventions, possible adverse effects, comorbidities, frailty, and the patient's individual preferences.

In young patients, expressing a low 10-year risk solely as a percentage may lead to the false impression that prevention is unnecessary, since the short-term absolute risk is low even in the presence of significant risk factors. Presenting the estimated benefit over the patient's entire lifetime, rather than exclusively over a 10-year period, can increase the patient's motivation and adherence to lifestyle changes and medication.

Several practical tools facilitate risk communication:

- using **natural frequencies** instead of percentages ("out of 100 people like you, about 12 will have a heart attack or stroke in the next 10 years");
- **visual representations** (diagrams with icons, simple graphs), which are easier to understand than numbers;
- the concept of **vascular age** and the estimation **of disease-free life years** gained through treatment;
- **the "teach-back" technique**, in which the patient is asked to explain in their own words what they have understood;
- **motivational interviewing**, which explores the patient's motivations and barriers rather than imposing recommendations.

Within the rehabilitation program, risk communication is not a one-time event but an ongoing process: the results achieved (lower blood pressure, lower LDL cholesterol, smoking cessation, increased exercise capacity) can be presented to the patient as concrete reductions in their risk, which reinforces their motivation to maintain these changes in the long term.

3.5. The Practical Utility of Cardiovascular Risk Assessment

In clinical practice, assessing a patient's cardiovascular risk can be viewed as a structured process, carried out in successive stages, which is particularly useful for graduate students encountering this type of assessment for the first time.

1. Determine whether the patient already has documented atherosclerotic cardiovascular disease, diabetes mellitus, chronic kidney disease, familial hypercholesterolemia, or another condition that directly places them in a high- or very-high-risk category based on clinical criteria.
2. If these conditions are absent and the patient is apparently healthy, the 10-year risk is estimated using SCORE2 (ages 40–69) or SCORE2-OP (≥ 70 years), using the calibration appropriate for the geographic region—in Romania, the calibration for countries with very high cardiovascular risk is required.
3. The patient is classified into the low-moderate, high, or very high risk category using the age-group-specific thresholds presented above.
4. The result is not interpreted mechanically: long-term risk, factors that may alter the initial estimate, comorbidities, degree of frailty, and the patient's preferences are further analyzed.

5. A preventive strategy appropriate to the risk category is established, and the response to the intervention is periodically reassessed to determine whether it is necessary to move to a higher level of treatment.

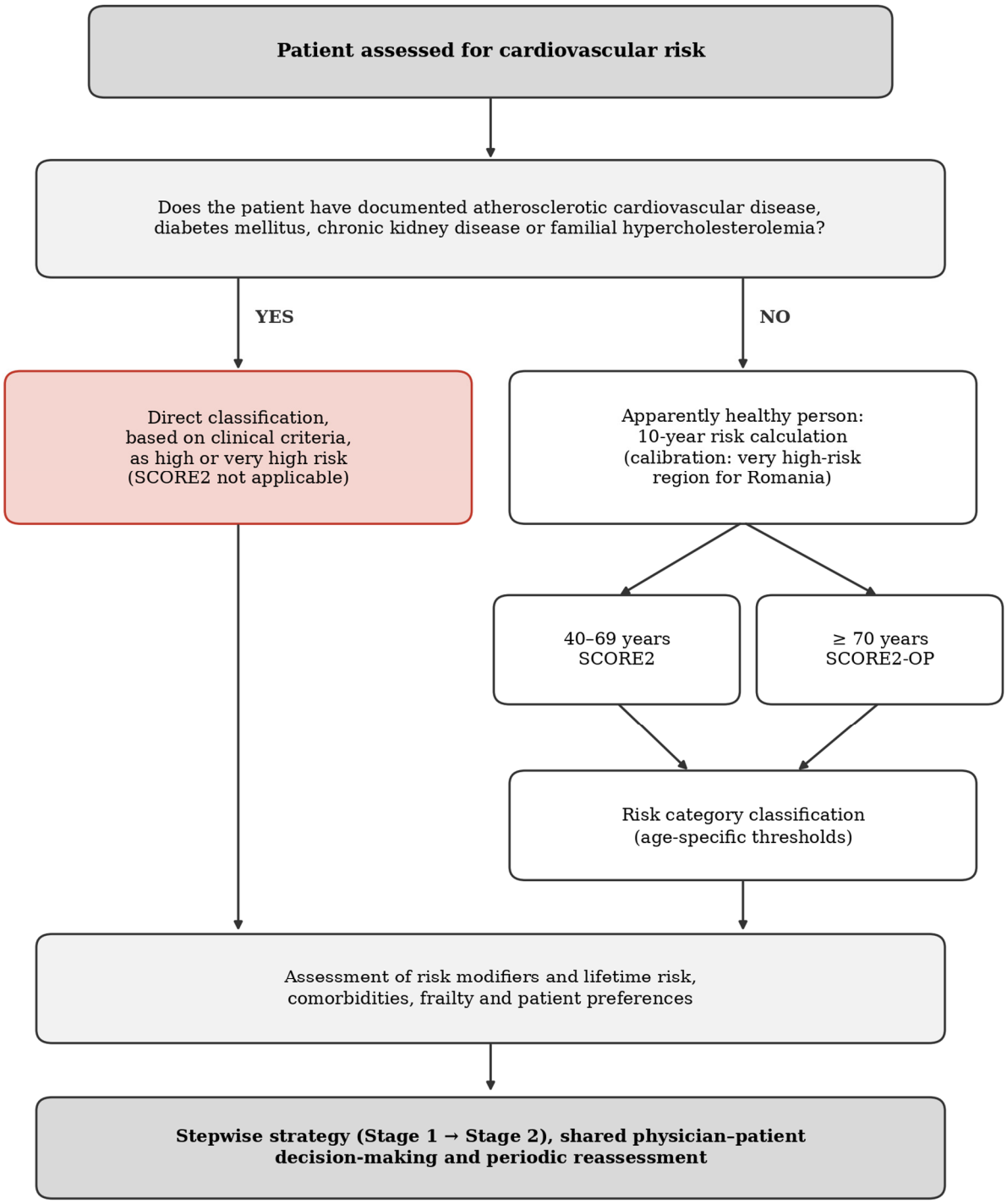


Figure 5. Practical algorithm for cardiovascular risk assessment and stratification.

Practical note: *This sequence of steps is useful as a teaching guide but does not replace individualized clinical reasoning: at each stage, the final decision must be integrated into the patient's specific context and discussed with the patient, in accordance with the principle of shared decision-making between physician and patient.*

3.6. Key Messages for Clinical Practice

1. Overall cardiovascular risk is more important than the isolated interpretation of a single risk factor.

2. SCORE2 estimates the 10-year risk of myocardial infarction and stroke, whether fatal or nonfatal, in apparently healthy individuals aged 40–69 years.
3. SCORE2-OP is used for individuals aged 70 years or older.
4. Romania belongs to the European region with very high cardiovascular risk, a calibration that must be used when estimating risk.
5. The SCORE2 cut-offs are age-dependent, being lower for younger individuals and higher for older adults.
6. SCORE2 is not used to assess risk in patients with documented atherosclerotic cardiovascular disease, diabetes mellitus, chronic kidney disease, or familial hypercholesterolemia, who require a specific evaluation based on direct clinical criteria.
7. In young patients, special attention should be given to lifetime risk and long-term benefit, even if the 10-year risk appears to be low.
8. Risk assessment should lead to an individualized decision made in consultation with the patient.
9. The ESC strategy is phased, beginning with the implementation of fundamental measures (Phase 1) and subsequently intensifying treatment toward the final therapeutic goals (Phase 2).
10. The higher the absolute cardiovascular risk, the greater the absolute benefit of reducing risk factors.
11. Most patients enrolled in rehabilitation programs have documented atherosclerotic cardiovascular disease and fall directly into the very high cardiovascular risk category. For them, the key question is not "What risk category do they fall into?" but "Have the therapeutic targets been met?"
12. For very-high-risk patients, the goals represent the ultimate target: LDL cholesterol below 55 mg/dL, with a reduction of at least 50%; systolic blood pressure of 120–129 mmHg, if tolerated; complete cessation of smoking; and adequate glycemic control. Risk remains heterogeneous even within this category: recurrent events, polyvascular disease, diabetes, and chronic kidney disease may warrant even stricter targets.
13. The recovery program provides the framework within which these targets are periodically assessed. The team monitors risk factors, alerts the attending physician to situations requiring intensified treatment, and presents each step of progress to the patient as a concrete reduction in personal risk.

Conclusions:

- Cardiovascular risk assessment and stratification form the foundation of modern cardiovascular prevention. The introduction of SCORE2 and SCORE2-OP allows for a more realistic estimate of the burden of cardiovascular disease by including both fatal and non-fatal events.
- The score should be interpreted based on age and geographic region—for Romania, the very-high-risk region—and supplemented by an assessment of long-term risk, risk-modifying factors, comorbidities, frailty, and patient preferences.
- For patients enrolled in rehabilitation programs, classification into the very-high-risk category is typically straightforward, and the focus is on achieving strict therapeutic goals.
- The ultimate goal is not simply to classify a patient into a risk category, but to select a personalized preventive strategy that strikes a favorable balance between benefit, safety, and the patient's individual preferences.

4. INDIVIDUALIZED STRATEGIES FOR REDUCING CARDIOVASCULAR RISK

4.1. General Considerations Regarding Preventive Interventions

Modern cardiovascular prevention involves not only identifying risk but also selecting interventions tailored to each patient. Knowing the therapeutic targets is not enough if the patient does not understand why they are important, is not motivated to change their behavior, or does not adhere to the prescribed treatment. For this reason, individualized risk-reduction interventions are based on several fundamental principles:

- **a patient-centered approach**: the intervention is based on the patient's needs, values, capabilities, and preferences, not just on the values of measured parameters;
- **shared decision-making between doctor and patient**: the patient is an active partner in choosing interventions, not merely a recipient of recommendations;
- **combining lifestyle measures with medication**: lifestyle changes are the foundation of prevention, but they do not replace pharmacological treatment when it is indicated; rather, they complement it;
- **a multidisciplinary approach**: the physician, physical therapist, nurse, dietitian, and psychologist each contribute, from their own perspective, toward the same goal;
- **continuity**: behavioral change is a long-term process that requires follow-up, reassessment, and long-term support.

The 2021 ESC Guidelines on the Prevention of Cardiovascular Disease emphasize that, before initiating any therapeutic measure, the benefits and risks of the intervention must be clearly explained to the patient. Even in situations where there are strong Class I or IIa recommendations, the final decision must be part of a shared decision-making process between the physician and the patient: some patients may consciously refuse treatment after receiving adequate information, while others, with an apparently lower risk, may be highly motivated to further reduce their risk. The intensity of the intervention should therefore not be determined mechanically, based solely on the calculated risk category.

The central concept remains the staged approach:

- **Stage 1**—implementation of fundamental prevention goals;
- **Stage 2** – intensifying interventions when cardiovascular risk, estimated long-term benefit, comorbidities, and patient preferences warrant it.

Preventive targets vary depending on age and the presence of diabetes, chronic kidney disease, familial hypercholesterolemia, or atherosclerotic cardiovascular disease. For patients enrolled in rehabilitation programs—most of whom have documented cardiovascular disease and very high risk—the targets are strict, and the individualized interventions described in this chapter are the tools through which these targets can be achieved and maintained over time.

- **Therapeutic Education and Treatment Adherence**

Therapeutic education aims to help patients acquire the knowledge and skills necessary to manage their condition and actively participate in their own treatment. It differs from mere information provision: it is not limited to conveying recommendations but seeks to ensure their understanding and translation into concrete behaviors.

Therapeutic education must be structured, tailored to the patient's level of understanding, and supported by simple written or visual materials. Key topics include:

- understanding the disease and the link between risk factors and cardiovascular events;
- recognizing warning signs and knowing what to do immediately if they occur;
- proper medication administration, the role of each medication, and possible side effects;
- self-monitoring: blood pressure, body weight, blood glucose levels in diabetic patients, and symptoms;
- necessary lifestyle changes: diet, physical activity, quitting smoking, limiting alcohol consumption, and stress management;
- the importance of regular checkups and continuing treatment over the long term, even in the absence of symptoms.

The effectiveness of therapeutic education increases when information is conveyed gradually, over several sessions, rather than concentrated into a single discussion at discharge. The recovery program provides the ideal framework for this process, through repeated contact with the patient over the course of several weeks. Both individual and group sessions are useful, as they allow patients to share experiences and support one another.

An important consideration is **the level of health literacy** (the patient's ability to understand and use medical information). For patients with limited education, the elderly, or those with cognitive impairment, messages should be simplified, repeated, and verified. The **"teach-back"** technique—in which the patient is asked to explain in their own words what they have understood—allows for the rapid identification and correction of misunderstandings.

- **Doctor–Patient Communication**

Effective communication is one of the fundamental elements of cardiovascular prevention. The physician or physical therapist must present recommendations in a personalized manner so that the patient understands both their own risk and the concrete benefits of lifestyle changes or adherence to medication.

A person's ability to adopt healthy behaviors is influenced by several individual factors:

- level of education and socioeconomic status;
- emotional state and mental health;
- perception of the disease and the severity of symptoms;
- subjective perception of personal risk;
- beliefs and past experiences related to illness and treatment;
- family and social support.

A few practical principles enhance the effectiveness of communication:

- using **simple language**, without unexplained medical terms;
- **actively listening** to the patient, allowing sufficient time for questions and for expressing fears;
- presenting risk using **natural frequencies** ("out of 100 people like you…") and **visual representations**, which are easier to understand than percentages;
- using the concepts of **vascular age** and **years of healthy life gained**, especially with younger patients;
- formulating **two or three key messages** at each appointment, rather than providing a large volume of information;
- **empathy** and avoiding a critical or blaming attitude, which undermines the patient's trust and openness.

Practical Note: *Medical information should be presented realistically, yet clearly enough for the patient to understand the real consequences of continuing to engage in risk factors—a difficult balance to achieve, but essential for effective communication.*

- **Techniques for Increasing Motivation to Change Lifestyle**

Behavioral change is difficult, and simply offering recommendations is often not enough. The 2021 ESC Guidelines recommend the use of cognitive-behavioral strategies, such as motivational interviewing, to support lifestyle changes.

A useful model for understanding the process of change is **the Transtheoretical Model of Stages of Change** (Prochaska and DiClemente), which describes the sequence of stages a person goes through when changing a behavior:

- **precontemplation**: the patient is not yet thinking about change and does not consider the behavior a problem;
- **contemplation**: the patient recognizes the problem but is ambivalent and has not yet made a decision;
- **preparation**: the patient intends to change in the near future and is taking the first steps;
- **action**: the patient has begun to actually change their behavior;
- **maintenance**: the new behavior is sustained over time, with relapse prevention.

Identifying the stage the patient is in allows the intervention to be tailored: for a patient in the precontemplation stage, the goal is not to establish an action plan, but to raise awareness; for a patient in the action stage, the focus is on support and relapse prevention.

Motivational interviewing is a patient-centered communication style that aims to explore and resolve ambivalence toward change, so that motivation comes from within rather than being imposed from the outside. A useful tool in this regard is the **OARS** principle:

- **O** – Open questions, for example: "What would help you get more exercise?";
- **A** – Affirmations and validation of progress, for example: "The fact that you've cut down on smoking shows that you can make this change";
- **R** – Reflective listening, by rephrasing what the patient has said to demonstrate understanding;
- **S** – Summarizing the discussion, by reviewing the main ideas and the steps agreed upon.

To set concrete goals with the patient, the **SMART** principle can be used as a complementary tool:

- **S** – Specific;
- **M** – Measurable;
- **A** – Achievable;
- **R** – Realistic;
- **T** – Time-bound.

For example, a vague goal such as "I will exercise more" can be transformed into a SMART goal: "I will walk for 30 minutes, 5 times a week, over the next 4 weeks." Small, successfully achieved goals boost the patient's confidence in their own ability to change and pave the way for the next goals.

These methods facilitate the patient's active involvement and help transform general recommendations into concrete, personalized goals. For older adults, it may also be helpful to involve a family member or close friend in goal-setting discussions.

- **Adherence to Medication**

Adherence refers to the extent to which the patient's behavior (taking medication, following lifestyle recommendations, attending follow-up appointments) aligns with the recommendations agreed upon with the healthcare team. Poor adherence is one of the main challenges in cardiovascular prevention. According to data cited in the guidelines, treatment adherence is estimated at approximately 50% in primary prevention and 66% in secondary prevention, and approximately 9% of cases of atherosclerotic cardiovascular disease in Europe could be attributed, at least in part, to insufficient adherence to medication therapy.

Adherence often declines over time, especially after the first few months following an acute event, when symptoms have improved and the patient perceives less need for treatment. Preventive medications, such as statins or antihypertensives, do not produce an improvement that is directly felt by the patient, which makes discontinuation common.

Common causes of poor adherence include:

- polypharmacy and complex medication regimens;
- a poor doctor-patient relationship;
- denial of the illness and fear of side effects;
- the absence of symptoms and the perception that treatment is no longer necessary;
- associated cognitive or mental health disorders, particularly depression;
- financial difficulties;
- social isolation.

Adherence can be assessed through direct questions, standardized questionnaires, counting pills, verifying that prescriptions have been filled, or, indirectly, by achieving therapeutic goals. No single method is perfect, and combining them provides a more realistic picture.

Practical Note: *Adherence assessment should be conducted in a non-judgmental manner: the patient should be asked directly, but without judgment, about difficulties related to taking the medication. Mobile apps and other digital solutions can help improve adherence, both for medication and for behavioral lifestyle changes.*

- **Strategies for Improving Adherence**
  - simplifying treatment regimens whenever possible, including through the use of fixed-dose **combinations** in a single tablet or a **polypill**, as recommended by the 2021 ESC guidelines to improve adherence;
  - Setting realistic goals, negotiated together with the patient (the SMART principle);
  - clearly explaining the role of each medication and its long-term benefits;
  - using self-monitoring (physical activity logs, blood pressure, weight);
  - using practical tools: daily pill organizers, phone alarms, mobile apps;
  - actively involving the family and the social support network;
  - identifying and treating depression and anxiety, which significantly reduce adherence;
  - scheduling regular follow-up visits, including via telemedicine when possible.

Table 6 . Common Barriers to Treatment Adherence and Practical Solutions

Barrier	**Practical Solutions**
Complex treatment regimen, large number of tablets	Simplify the regimen; use fixed-dose combinations or a single-pill regimen; administer once daily; provide daily pill packs
Missed doses	Phone alarms, mobile apps, linking medication intake to a daily routine (e.g., breakfast)
Fear of side effects	Explaining actual side effects and their frequency, discussing alternatives, encouraging the reporting of any symptoms
Absence of symptoms, perception that treatment is no longer necessary	Explaining the preventive role of treatment and the risks associated with discontinuation, presenting the results achieved (blood pressure, LDL-C levels)
Depression, anxiety, cognitive impairment	Screening, assessment, and specialized treatment; involving the family; simplifying instructions
Financial difficulties	Choosing, together with the doctor, subsidized or more affordable alternatives
Social isolation, lack of support	Family involvement, group recovery programs, telemonitoring, regular contact with the medical team

- **The role of the rehabilitation team**

The cardiovascular rehabilitation program provides an ideal setting for implementing these interventions. Repeated contact with the patient—two to three times a week for several weeks—allows for:

- the gradual conveyance of information and verification of its understanding;
- identifying the stage of change the patient is in and adapting the intervention;
- the establishment and periodic reassessment of SMART goals;
- checking adherence to treatment at each session, in a non-judgmental manner;
- presenting progress as concrete reductions in personal risk, which serves as a motivator;
- preparing the patient for Phase III, in which maintaining the changes depends primarily on the patient.

Summary: *Reducing cardiovascular risk depends not only on knowing the therapeutic targets but also on the team's ability to actively engage the patient. Structured therapeutic education, clear and empathetic communication, motivation-enhancing techniques (motivational interviewing, the OARS and SMART principles), and strategies to improve adherence are essential tools that transform general recommendations into sustainable behaviors. The cardiovascular rehabilitation program provides the ideal framework for their application.*

4.2. Smoking Cessation—A Priority Intervention for Reducing Cardiovascular Risk

- **Smoking—a major modifiable risk factor**

Smoking is one of the most important modifiable cardiovascular risk factors and one of the leading causes of preventable death. It acts through several mechanisms common to all vascular systems: endothelial damage and endothelial dysfunction, oxidative stress, systemic inflammation, increased platelet aggregability and fibrinogen levels, vasoconstriction, decreased HDL cholesterol, and increased carboxyhemoglobin levels, which reduce oxygen-carrying capacity. The result is accelerated atherosclerosis and an increased risk of thrombosis, affecting the coronary, cerebral, and peripheral circulatory systems.

The risk associated with smoking has no safe threshold: even light smoking—just a few cigarettes a day—is associated with a significantly increased cardiovascular risk. For this reason, reducing the number of cigarettes is not an acceptable alternative to quitting completely.

Completely quitting smoking is considered one of the most effective preventive cardiovascular interventions, reducing the risk of myocardial infarction, recurrence of cardiovascular events, and mortality. The benefits are seen at all ages, and the guidelines estimate that quitting smoking can result in gains of several years of life free from myocardial infarction or stroke. Even among smokers who smoke 20 or more cigarettes a day, cardiovascular risk begins to decrease significantly as early as the first few years after quitting.

In secondary prevention, the benefit is particularly significant: quitting smoking after a coronary event is associated with a reduction in mortality of about one-third, comparable to or even greater than the effect of many drug therapies. In patients with peripheral artery disease, smoking is the strongest risk factor, and continuing to smoke after revascularization significantly increases the risk of bypass or stent occlusion and the risk of amputation.

Table 7 . Benefits of quitting smoking over time (guideline values)

Time since quitting	Benefit
First few hours	Decrease in heart rate and blood pressure; decrease in blood carbon monoxide levels
First weeks–months	Improved circulation and lung function; reduced coughing and shortness of breath; improved exercise tolerance
Approximately 1 year	The risk of coronary heart disease is reduced to about half that of an active smoker
5–15 years	The risk of stroke approaches that of a nonsmoker
About 15 years	The risk of coronary heart disease approaches that of a person who has never smoked

• ESC Recommendations on Smoking

- ✓ **Complete cessation of smoking** in all forms, regardless of any associated weight gain.
- ✓ **Behavioral support, nicotine replacement therapy, varenicline**, **or bupropion** for smokers who wish to quit; the combination of behavioral counseling and medication is most effective.
- ✓ **Avoid secondhand smoke**, as exposure to tobacco smoke is an independent cardiovascular risk factor.
- ✓ **Ask about smoking status at every medical visit** and document it in the patient's medical record.

• Assessment of the smoker

Before intervention, several assessment elements are useful:

- **smoking status and consumption**: number of cigarettes per day, duration of smoking (also expressed in pack-years), type of product (conventional cigarettes, e-cigarettes, heated tobacco products);

- **the degree of nicotine dependence**, as assessed, for example, by **the Fagerström test**; a simple indicator is the time until the first cigarette after waking up: less than 30 minutes indicates a high level of dependence;
- **motivation and stage of change** (precontemplation, contemplation, preparation, action, maintenance);
- **previous attempts to quit** and reasons for relapse;
- **measurement of carbon monoxide in exhaled air**, when available, as an objective indicator of recent smoking and as a motivational feedback tool.

• Brief intervention for smoking cessation

The guide presents a simple strategy that can be implemented in as little as 30 seconds and is useful in any medical consultation, regardless of specialty:

- **ASK** – ask about and document the patient's smoking status;
- **ADVISE (advise)** – recommend quitting and explain the most effective method available;
- **ACT (take action)** – provide concrete help, either through direct counseling or by referring the patient to a specialized program.

Even this very brief intervention significantly increases the likelihood that the patient will try to quit, which is why every member of the healthcare team, including the physical therapist, should implement it.

• The "5A" Model

When time allows for a more structured intervention, as is the case in a rehabilitation program, **the "5A" model**—widely recommended in smoking cessation counseling—can be used:

Table 8 . The "5A" Model for Smoking Cessation Counseling

Stage	What it involves	Practical Example
ASK	Identify and document smoking status at every visit	"Do you smoke? How many cigarettes a day?"
ADVISE	Clear, firm, and personalized recommendation to quit	"Quitting smoking is the most important thing you can do for your heart after a heart attack."
ASSESS	Assess the patient's readiness to quit at this time	"Would you be willing to try to quit within the next month?"
ASSIST	Practical support: setting a quit date, action plan, counseling, medication, educational materials	Setting a quit date, identifying risk factors, physician's recommendation for medication
ARRANGE (organize follow-up)	Scheduling follow-up contacts, especially in the first few weeks after quitting	Checking status at each recovery session; phone follow-up during the first week

For patients who **are not yet ready** to quit, the intervention does not stop. The motivational **"5R"** approach can be used: **the relevance** of quitting to the patient's personal situation, **the risks** of continuing to smoke, **the rewards** (benefits) of quitting, **the** perceived **obstacles** (barriers), and **repeating** the message at every contact. The goal is to gradually increase motivation until the patient is ready to attempt to quit.

• Pharmacological Treatment of Nicotine Dependence

For smokers motivated to quit, pharmacological support should be considered, as it significantly increases the chances of success, especially when combined with behavioral counseling. The options mentioned in the guidelines include nicotine replacement therapy, varenicline, bupropion, and cytisine.

Table 9 . Pharmacological options for the treatment of nicotine dependence

Medication	Key characteristics
Nicotine replacement therapy	Slow-release (patch) and rapid-release (gum, tablets, spray) forms; combining the patch with a rapid-release form increases the success rate; safe for patients with stable cardiovascular disease
Varenicline	Partial nicotinic receptor agonist; significantly increases the abstinence rate; typically administered for 12 weeks; may be used in selected patients, including those who have experienced an acute coronary syndrome
Bupropion	Antidepressant effective in reducing the urge to smoke; contraindicated in patients with a history of seizures and in those with eating disorders
Cytisine	Partial nicotinic receptor agonist, related to varenicline; effective and low-cost; short-term treatment

The various forms of nicotine replacement therapy are effective, and combining multiple forms can increase the success rate. Prescribing and monitoring pharmacological treatment are the responsibility of the physician, but the recovery team plays an important role in supporting adherence and identifying adverse effects.

• Nicotine Withdrawal and Relapse Prevention

Withdrawal symptoms may occur in the first few days and weeks after quitting: irritability, anxiety, difficulty concentrating, sleep disturbances, increased appetite, and intense cravings to smoke. These symptoms peak during the first week and gradually subside over the following weeks. Pharmacological treatment reduces their intensity.

Relapse is common, especially in the first few months, and should not be viewed as a definitive failure, but rather as a stage in the process of quitting. Most former smokers made several attempts before succeeding. Preventing relapses involves identifying high-risk situations (stress, alcohol or coffee consumption, being around smokers), developing alternative strategies to manage them, and staying in touch with your healthcare team.

• Weight Gain After Quitting Smoking

After quitting smoking, an average weight gain of about 5 kg may occur. This should not discourage quitting and should not be used as a reason to delay quitting, as the cardiovascular and overall health benefits of quitting smoking significantly outweigh the risk associated with weight gain, which can later be managed through dietary intervention and physical exercise. In the recovery program, physical training and nutritional counseling directly help limit this weight gain.

• E-cigarettes and "heat-not-burn" products

In the 2021 ESC document, e-cigarettes are considered likely to be less harmful than conventional cigarettes, as exposure to some combustion byproducts is reduced; at the time the guidelines were drafted, data suggested that they might be more effective than nicotine replacement therapy for smoking cessation. However, the long-term cardiovascular and pulmonary effects were not sufficiently understood at that time. The guidelines make the following clarifications:

- the concurrent use of e-cigarettes and conventional cigarettes should be avoided, as it does not provide the benefit of complete cessation;
- "heat-not-burn" products (which heat tobacco without burning it) still contain tobacco and, according to the document, should be avoided;
- the ultimate goal remains complete cessation of any product containing tobacco or nicotine.

Knowledge in this field is evolving rapidly, and practitioners should stay abreast of the latest positions from relevant professional societies.

• The Role of the Rehabilitation Team in Smoking Cessation

The cardiovascular rehabilitation program provides a particularly favorable setting for smoking cessation. The period following an acute event is when the patient is most motivated, and repeated contact with the team—two to three times a week—allows for the full implementation of the "5A" model:

- documenting smoking status during the initial assessment and verifying it at each session;
- setting a quit date, ideally within the first few weeks of the program;
- collaborating with the physician to initiate pharmacological treatment;
- directly linking smoking cessation to program outcomes: improved exercise tolerance, reduced shortness of breath, and, in patients with peripheral artery disease, increased walking distance;
- involving the family, including efforts to reduce exposure to secondhand smoke;
- preventing relapses and preparing the patient to maintain abstinence after completing the program.

Practical Note: *Asking "Do you smoke?" takes only a few seconds, but repeating this question at every visit—accompanied by a firm recommendation and the offer of concrete support—has a significant cumulative impact. Smoking cessation should be treated as a therapeutic component of the rehabilitation program, just as important as physical training.*

Summary: *Complete smoking cessation is one of the most effective interventions for reducing cardiovascular risk, with benefits at any age and at any stage of the disease. The intervention combines assessment of the smoker, structured counseling based on the "5A" model, the motivational "5R" approach for unprepared patients, pharmacological treatment of addiction, and relapse prevention. The cardiovascular rehabilitation program provides the ideal framework for implementing this comprehensive strategy.*

4.3. Principles of Cardioprotective Nutrition in Secondary Prevention

Nutritional intervention is a mandatory component of any cardiovascular rehabilitation program, with a demonstrated impact on lipid profile, blood pressure, body weight, and carbohydrate metabolism. The general principles recommended by prevention guidelines include reducing the intake of saturated and trans fats, limiting sodium intake, increasing the intake of fiber, fruits, and vegetables, as well as moderating total caloric intake according to individual needs.

The 2021 ESC Guidelines recommend, first and foremost, adopting a Mediterranean-style or similar dietary pattern (Class I, Level A), with the general principle being to orient the diet toward predominantly plant-based foods and to reduce ultra-processed foods, as well as excessive intake of saturated fats, salt, and sugar.

An important principle of modern nutrition is the shift from an approach focused on isolated nutrients (e.g., "less cholesterol" or "less fat") to one centered on **dietary patterns** and **whole foods**. The effect of a diet is not the sum of the effects of individual nutrients, but rather the result of the combination of foods consumed daily. For this reason, practical recommendations for patients should be formulated in terms of specific foods and eating habits, not in grams of nutrients that are difficult to quantify in everyday life.

- **Nutritional Assessment of the Patient**

Effective nutritional intervention begins with an assessment of the patient's eating habits and nutritional status:

- **dietary history**: the number and timing of meals, consumption of processed foods, salt, sweets and sweetened beverages, alcohol, and the habit of eating out; a useful tool is **a food diary** kept over the course of several days;
- **adherence to the Mediterranean diet**, which can be assessed using short, standardized questionnaires, such as the 14-question MEDAS questionnaire used in the PREDIMED study;
- **anthropometric parameters**: weight, body mass index, waist circumference;
- **assessment of the risk of malnutrition and sarcopenia**, particularly in older patients or those with advanced heart failure, for example through nutritional screening tools and muscle strength assessment;
- **factors influencing diet**: socioeconomic status, who prepares meals in the family, cultural and religious preferences, comorbidities (diabetes, chronic kidney disease, swallowing disorders).

- **The Mediterranean Diet**

The Mediterranean diet, characterized by a high intake of vegetables, fruits, legumes, whole grains, fish, and olive oil, combined with reduced consumption of red meat, processed foods, and saturated fats, is one of the dietary patterns with the strongest evidence supporting its role in cardiovascular prevention. Adherence to this dietary pattern is associated, according to available data, with a reduction in cardiovascular incidence and mortality, making it the reference model recommended by current European guidelines.

The PREDIMED study, conducted among individuals at high cardiovascular risk, showed that a Mediterranean diet supplemented with extra-virgin olive oil or nuts was associated with a reduction in major cardiovascular events compared to a low-fat diet. The benefits of the Mediterranean diet are attributed to a combination of several factors: a favorable fat profile (predominantly monounsaturated and polyunsaturated fats), high fiber, antioxidant, and polyphenol content, as well as low intake of processed foods.

A related dietary pattern is **the DASH** (Dietary Approaches to Stop Hypertension) **diet**, which is rich in vegetables, fruits, whole grains, and low-fat dairy products, and low in sodium and saturated fats. The DASH diet has a proven effect in lowering blood pressure and represents a useful alternative, particularly for patients with hypertension.

For patients in Romania, adapting the Mediterranean model to local foods is essential for adherence: seasonal vegetables, beans and lentils, fish, olive or canola oil, nuts, and local fruits can successfully replace elements of the traditional diet that are high in animal fats, processed meats, and salt.

- **Characteristics of the Cardioprotective Diet**

The ESC guidelines summarize the quantitative characteristics of the cardioprotective diet as follows:

Table 10 . Quantitative characteristics of the cardioprotective diet

Component	**Recommendation**
Saturated fats	< 10% of total energy
Trans fats	As little as possible; avoid as much as possible
Salt	< 5 g/day
Fiber	30–45 g/day
Fruit	≥ 200 g/day
Vegetables	≥ 200 g/day
Red meat	up to about 350–500 g/week
Processed meat	as little as possible
Fish	1–2 times per week
Unsalted nuts	about 30 g per day
Alcohol	up to 100 g of pure alcohol per week
Sweetened beverages	not recommended

A simple way to convey these recommendations to the patient is **the plate model**: half the plate should consist of fruits and vegetables, one-quarter of whole grains or legumes, and one-quarter of protein sources (fish, lean meat, legumes), with vegetable oil in moderation and water as the primary beverage.

• Dietary fats

Simply reducing fat intake is not enough; what is essential is what saturated fats are replaced with. Replacing them with polyunsaturated fatty acids, monounsaturated fatty acids, or carbohydrates from whole grains is associated with a reduced risk of coronary heart disease, and the guidelines explicitly recommend this substitution (Class I, Level A). Replacing saturated fats with refined carbohydrates (white bread, pastries, sugar), however, does not provide the same benefit.

Saturated fats are found mainly in fatty meats, processed meats, lard, butter, cream, full-fat cheeses, as well as in palm and coconut oils. Recommended sources of unsaturated fats include olive oil and other vegetable oils (canola, sunflower), nuts and seeds, avocados, and fatty fish.
Trans fats should be reduced as much as possible, since an increase in energy intake from trans fats is associated with a significant increase in the risk of coronary heart disease. They are found mainly in products containing partially hydrogenated vegetable fats (some margarines, industrial pastries and cookies, and fried foods) and raise LDL cholesterol while lowering HDL cholesterol.

• Salt intake

Reducing sodium intake lowers blood pressure, with a more pronounced effect in patients with hypertension—the guidelines note an average reduction in systolic blood pressure of approximately 5.8 mmHg in hypertensive patients following a reduction in sodium intake. The maximum recommended intake is less than 5 g of salt per day, whereas actual intake in many populations is close to 9–10 g/day, making the reduction of processed foods a top practical priority.
Most of the salt consumed does not come from salt added at the table, but from **processed foods**: bread, deli meats, salty cheeses, canned foods, pickles, instant soups, sauces, and salty snacks. Some practical recommendations for patients:

- read food labels: the amount of salt can be roughly calculated by multiplying the sodium content by 2.5;
- limit your intake of cold cuts, pickles, and salty cheeses;
- cook at home, adding only a small amount of salt, and use spices, herbs, and lemon for flavor;
- avoiding having a salt shaker on the table;
- gradually adjusting your taste buds: the preference for salt decreases after a few weeks of reduced intake.

Potassium-based salt substitutes may be helpful for some patients, but they should be used with caution in those with chronic kidney disease or those taking medications that increase potassium levels (angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, mineralocorticoid receptor antagonists), due to the risk of hyperkalemia.

• Dietary fiber

Higher dietary fiber intake is associated with a reduced risk of coronary heart disease, stroke, and type 2 diabetes. The guidelines state that each increase of approximately 7 g/day in fiber intake is associated with a reduction of approximately 9% in coronary risk. The recommended intake is 30–45 g of fiber per day, preferably from whole grains, vegetables, fruits, and legumes.
Soluble fiber (from oats, barley, legumes, and fruits) helps lower LDL cholesterol, and fiber in general increases feelings of fullness and improves blood sugar control. Increasing fiber intake should be done gradually, along with adequate fluid intake, to avoid digestive discomfort.

• Fruits, vegetables, and legumes

Regular consumption of fruits and vegetables is associated with lower cardiovascular mortality and a reduced risk of stroke. The practical recommendation is a minimum of 200 g of fruit per day and a minimum of 200 g of vegetables per day, which corresponds, approximately, to 2–3 servings of each. Variety is recommended, and whole fruits should be preferred over juices, which are high in sugar and low in fiber.
Consuming legumes (beans, lentils, chickpeas, peas) is also beneficial, as it is associated with a reduction in LDL cholesterol. Legumes are a valuable source of plant-based protein, fiber, and minerals and can partially replace meat in your weekly diet.

• Nuts

Consuming about 30 g of unsalted nuts per day (about a handful) is consistent with the recommended dietary pattern. The epidemiological data analyzed in the guidelines suggest an association between regular nut consumption and a lower risk of atherosclerotic cardiovascular disease. However, nuts are high in calories, which is why they should be consumed in place of other snacks, not in addition to them, especially for overweight patients.

• Meat

It is recommended to limit meat consumption, especially that of processed meats. Red meat should be limited to approximately 350–500 g per week, and consumption of processed meats (cold cuts, sausages, salami, bacon) should be kept as low as possible, as they combine a high saturated fat content with a high salt content. Lean meats (chicken, skinless turkey) and healthy cooking methods (boiling, braising, baking, grilling) are preferred over frying. Partially replacing meat with plant-based protein sources is beneficial for lipid profile.

• Fish

Consuming fish, especially fatty fish (salmon, mackerel, sardines, herring), is recommended about 1–2 times a week; according to the data presented in the guidelines, eating fish at least once a week is associated with a reduced risk of coronary heart disease. Fatty fish is an important source of omega-3 fatty acids. However, standard fish oil supplements have not consistently demonstrated the same cardiovascular benefits observed with the consumption of fish as a food. A different situation applies to high-dose icosapent ethyl, a prescription medication for selected patients with elevated triglycerides, which should not be confused with dietary supplements.

• Alcohol consumption

The guidelines recommend limiting alcohol consumption to a maximum of 100 g of pure alcohol per week for both women and men. The analyzed data call into question the hypothesis that moderate alcohol consumption has a cardioprotective effect: genetic studies do not support a cardioprotective benefit of alcohol, and the lowest cardiovascular risks are often observed in abstainers. Furthermore, any increase in alcohol intake can contribute to elevated blood pressure and body weight. Excessive consumption is also associated with atrial fibrillation, toxic cardiomyopathy, and hypertriglyceridemia.

Practical Note: *Alcohol should not be recommended as a cardiovascular prevention strategy, and a patient who does not drink should not be encouraged to start drinking alcohol for purported cardioprotective purposes.*

• Sugar and Sweetened Beverages

Sugar intake should be limited to a maximum of approximately 10% of total energy intake. Sugar-sweetened beverages are associated with an increased cardiometabolic risk and should be actively discouraged during nutritional counseling. They provide a significant caloric intake without promoting a feeling of fullness and contribute to weight gain, insulin resistance, and hypertriglyceridemia. “Hidden” sugar is also found in many seemingly healthy products: fruit yogurts, breakfast cereals, fruit juices, and sauces. Water should be your main beverage.

• Coffee

Unfiltered coffee (boiled, Turkish-style, or brewed in a French press) contains cafestol and kahweol, substances that can raise LDL cholesterol, and very high consumption of unfiltered coffee may have adverse cardiovascular effects. In contrast, moderate consumption of filtered coffee—about 3–4 cups per day—is considered likely safe and may even offer moderate benefits. For patients with arrhythmias, anxiety, or uncontrolled hypertension, consumption should be tailored to the individual.

• Supplements and Functional Foods

Phytosterols, at a dose of approximately 2 g/day, can reduce LDL cholesterol by about 10%, but there is insufficient data on their effect on major cardiovascular events. Red yeast rice supplements are not recommended, as they may cause adverse reactions, and routine supplementation with vitamins (A, E, B, C, or D) has not demonstrated a clear cardiovascular benefit in interventional studies. Patients should be informed that supplements cannot replace prescribed lipid-lowering therapy and should be actively asked about the supplements they are taking, as some may interact with cardiovascular medications.

- **Nutritional Considerations for Cardiovascular Patients**

General recommendations should be tailored to each patient’s specific condition and treatment:

  - **heart failure**: salt restriction should be individualized, avoiding both excess and very severe restrictions, which can exacerbate malnutrition; fluid intake should be adjusted

according to the patient's clinical status, as recommended by the physician; in patients with advanced disease, the risk of cardiac cachexia should be monitored;

- **diabetes mellitus**: emphasis on controlling the quantity and quality of carbohydrates and fiber, and on avoiding simple sugars and sweetened beverages;
- **Chronic kidney disease**: Protein, potassium, and phosphorus intake should be adjusted according to the stage of the disease, in consultation with the nephrologist and dietitian;
- **anticoagulant therapy with vitamin K antagonists**: vitamin K intake (from leafy green vegetables) should not be eliminated but kept constant to avoid fluctuations in INR levels;
- **food–drug interactions**: grapefruit juice can increase blood levels of certain statins (especially simvastatin) and other cardiovascular medications;
- **Elderly and frail patients**: The priority is to prevent malnutrition and sarcopenia through an adequate protein intake (approximately 1.0–1.2 g/kg/day, if renal function permits), while avoiding excessive dietary restrictions.

- **Weight Management**

Obesity, particularly abdominal obesity, is independently associated with an increased cardiovascular risk. In overweight and obese patients, the guidelines recommend weight loss to improve blood pressure, lipid profile, and glucose metabolism. It is important to note, as a practical guideline for patient counseling, that even a weight loss of approximately 5–10% of initial body weight can result in significant metabolic benefits, without the need to reach an "ideal" weight to achieve a clinically relevant benefit.

Weight loss should be gradual—approximately 0.5–1 kg per week—achieved by combining a moderate calorie deficit with regular physical activity. Incorporating resistance training is important for preserving muscle mass. Maintaining the achieved weight in the long term is the most challenging stage and requires ongoing monitoring and support.

- **Weight-Loss Diets**

The fundamental element of weight loss remains achieving a calorie deficit. Several types of diets can lead to weight loss—low-calorie Mediterranean diets, plant-based diets, low-carbohydrate diets, low-fat diets, high-protein diets, or intermittent fasting—and in the short term, the differences between these strategies are relatively small in terms of kilograms lost. The key factors for long-term success are the quality of the foods chosen and the patient's actual ability to maintain that diet over time.

Highly restrictive or "fad" diets, which eliminate entire food groups, are difficult to sustain and can lead to nutritional deficiencies and rapid weight regain. For patients with cardiovascular disease, the choice of strategy must also take into account comorbidities and associated treatments.

- **Pharmacological Treatment and Bariatric Surgery**

In patients with obesity for whom lifestyle interventions are insufficient, pharmacological treatment may be considered. GLP-1 receptor agonists (e.g., semaglutide) and dual GIP/GLP-1 agonists (tirzepatide) produce significant weight loss, and semaglutide has been shown to reduce cardiovascular events in patients with atherosclerotic cardiovascular disease and overweight or obesity, without diabetes. In these patients, adequate protein intake and resistance training are essential to limit muscle mass loss.

In patients with severe obesity and high cardiovascular risk, bariatric surgery may be considered when lifestyle interventions fail to achieve and maintain adequate weight loss (Class IIa, Level B). According to the data cited in the guidelines, bariatric surgery has been associated with a significant reduction in mortality among carefully selected individuals with severe obesity.

- **The Role of the Rehabilitation Team in Nutritional Intervention**

The cardiovascular rehabilitation program provides an ideal setting for nutritional intervention, thanks to repeated contact with the patient and a multidisciplinary approach. Each team member has a specific role:

- **the physician** sets therapeutic goals (weight, lipid profile, blood pressure, glycemic control), identifies specific issues related to the patient's condition and treatment, and coordinates the intervention;
- **the nutritionist (dietitian)** performs a detailed nutritional assessment, develops a personalized meal plan, and provides nutritional counseling, either individually or in a group setting;
- **The physical therapist** integrates physical activity into the weight management strategy, supports the maintenance of muscle mass through resistance training, and reinforces key nutritional messages at each session;
- **The medical assistant** periodically monitors weight, waist circumference, and blood pressure and verifies that the patient understands the recommendations;
- **the psychologist** intervenes when eating behavior is influenced by stress, anxiety, depression, or emotional eating.

In practice, the nutritional intervention within the recovery program includes:

- **an initial assessment** of eating habits, nutritional status, and anthropometric parameters;
- **setting concrete and realistic goals**, formulated according to the SMART principle (for example, "I will replace processed meats at breakfast with low-fat cheese and vegetables at least 5 times a week");
- individual or group **nutrition education sessions** covering practical topics: reading labels, choosing foods while shopping, healthy cooking methods, and meal planning;
- **Involving the family**, especially the person who prepares the meals, because dietary changes are much easier to maintain when adopted by the entire family;
- **regular monitoring** of weight, waist circumference, and metabolic profile, and adjusting recommendations based on the results;
- **a reassessment at the end of the program** and the establishment of a long-term maintenance plan, which is shared with the family doctor.

Practical Note: *Nutritional recommendations are most effective when they are few in number, specific, and tailored to the patient's habits. It is preferable for the patient to consistently implement two or three simple changes rather than receive a long list of restrictions that are difficult to follow in daily life.*

Summary: *Nutritional intervention is an essential component of the cardiovascular rehabilitation program. The Mediterranean-style diet, adapted to local habits—with a reduction in saturated fats, salt, sugar, and ultra-processed foods, and an increase in the consumption of vegetables, fruits, legumes, whole grains, fish, and nuts—forms the foundation of these recommendations. The intervention must be tailored to the patient's condition, treatment, age, and preferences, and the multidisciplinary rehabilitation team is responsible for transforming these recommendations into sustainable eating habits.*

4.4. The Role of Physical Activity in Reducing Cardiovascular Risk

Physical activity is one of the most effective non-pharmacological interventions in cardiovascular prevention. It acts simultaneously on multiple risk factors and on the pathophysiological mechanisms of cardiovascular disease, which is why it is rightly considered a true "medicine" with multiple effects.

A distinction must be made between several related concepts:

- **physical activity** encompasses any movement of the body produced by the skeletal muscles that results in energy expenditure above that at rest (walking, household chores, climbing stairs, work-related activities);
- **physical exercise** is a planned, structured, and repetitive form of physical activity aimed at maintaining or improving physical fitness;
- **physical training** is the systematic application of physical exercise, with prescribed parameters (frequency, intensity, duration, type), as carried out in a rehabilitation program;

- **functional capacity (cardiorespiratory fitness)** is the body's ability to transport and utilize oxygen during exercise, expressed as peak VO_2 or metabolic equivalents (METs).

There is a consistently demonstrated inverse relationship between the level of physical activity and overall mortality, cardiovascular mortality, cardiovascular morbidity, and the onset of type 2 diabetes. The benefit is evident even at low levels of activity, and the greatest relative reduction in risk is observed when a previously sedentary person becomes active—which is why, in cardiovascular rehabilitation, even modest improvements from baseline have real clinical value. Cardiorespiratory fitness is, in turn, one of the strongest predictors of mortality, and every increase in exercise capacity—even by 1 MET—is associated with a reduction in risk.

• The Benefits of Physical Activity

Regular physical activity has beneficial effects on nearly all of the body's systems. At the cardiovascular and metabolic levels, the main mechanisms through which it reduces risk are:

- **improved endothelial function**, through increased bioavailability of nitric oxide, with vasodilatory and antiatherogenic effects;
- **lowering blood pressure** by a few mmHg with regular aerobic exercise, an effect that is more pronounced in patients with hypertension;
- **improvement in the lipid profile**, particularly through a reduction in triglycerides and an increase in HDL cholesterol;
- **increased insulin sensitivity** and improved glycemic control, reducing the risk of type 2 diabetes;
- **reduction in body weight and visceral fat**, especially when combined with nutritional intervention;
- **reducing systemic inflammation** and oxidative stress;
- **balancing the autonomic nervous system**, with increased parasympathetic tone, decreased resting heart rate, and increased heart rate variability, with a protective antiarrhythmic effect;
- **antithrombotic effects**, through reduced platelet aggregability and improved fibrinolysis;
- **peripheral adaptations**: increased capillaryization and oxidative capacity of skeletal muscles, leading to more efficient oxygen utilization and reduced cardiac workload for the same physical exertion.

The benefits extend beyond the cardiovascular system: maintenance of muscle and bone mass, improved balance and reduced risk of falls, improved sleep quality, favorable effects on mental well-being (reduction of anxiety and depression symptoms, increased self-confidence), as well as protective effects on cognitive function.

In patients with established cardiovascular disease, physical training as part of rehabilitation programs is associated with reduced cardiovascular mortality and readmissions, increased exercise capacity, and improved quality of life. In patients with heart failure, exercise improves symptoms, exercise tolerance, and quality of life and reduces hospitalizations, while in patients with peripheral artery disease, it significantly increases walking distance.

Table 11 . The main benefits of regular physical activity

Area	**Benefit**
Mortality	Reduction in overall and cardiovascular mortality, proportional to increased activity levels and exercise capacity
Blood pressure	Lower resting blood pressure, especially in hypertensive patients
Lipid Profile	Decrease in triglycerides, increase in HDL cholesterol
Carbohydrate metabolism	Increased insulin sensitivity, improved glycemic control, prevention of type 2 diabetes
Body weight	Reduction of visceral fat and weight maintenance after weight loss

Area	Benefit
Vascular function	Improved endothelial function, reduced inflammation and oxidative stress
Autonomic nervous system	Decreased resting heart rate, increased heart rate variability
Functional capacity	Increased peak VO2 and exercise tolerance, reduced shortness of breath and fatigue
Musculoskeletal system	Maintaining muscle mass and strength, bone density, and balance; preventing falls
Mental and cognitive health	Reducing anxiety and depression; improving sleep and cognitive function

• ESC Recommendations on Physical Activity Volume

For adults of all ages, the 2021 ESC guidelines recommend a minimum of 150–300 minutes per week of moderate-intensity aerobic activity, or 75–150 minutes per week of vigorous-intensity activity, or an equivalent combination of the two. Physical activity should be spread out over the course of the week, ideally on most days. The guidelines also specify:

- for individuals who cannot achieve the minimum of 150 minutes of moderate-intensity activity per week, it is recommended that they remain as active as possible, within the limits of their functional capacity and health status (Class I, Level B);
- reducing the amount of time spent being sedentary is also recommended, regardless of whether the aerobic activity target is met (Class I, Level B);
- strength training should be performed on at least two days per week, in addition to aerobic activity (Class I, Level B).

The benefit increases with the volume of activity, as there is a dose–response relationship: exceeding the minimum of 150 minutes per week provides additional benefits. In patients with cardiovascular disease, these general recommendations apply following clinical evaluation and exercise testing, with training parameters tailored to the individual.

• Principles of Exercise Prescription—the FITT Model

Exercise prescription for cardiovascular rehabilitation follows the FITT principle (Frequency, Intensity, Time, Type), individually tailored according to the risk category determined by exercise testing, supplemented by the principle of gradual progression in volume and intensity. The extended version of this model, **FITT-VP**, explicitly includes total exercise **volume** (the product of frequency, intensity, and duration) and **progression**.

Table 12.a. Physical activity prescription based on the FITT model

Component	Guideline
Frequency	3–5 sessions per week of aerobic exercise
Intensity	Moderate (40–70% of functional reserve capacity), adjusted according to the patient's risk
Time (duration)	20–60 minutes per session, including warm-up and cool-down periods
Type	Aerobic exercises (walking, stationary bike), supplemented with progressive resistance training

Intensity is the most important parameter and the most difficult to determine. It can be determined using several methods, listed in order of accuracy:

- **based on a cardiopulmonary exercise test**: percentage of peak VO2 or heart rate corresponding to ventilatory thresholds (VT1, VT2)—the most accurate method;
- **based on reserve heart rate** (Karvonen formula): Target HR = resting HR + (peak HR – resting HR) × desired intensity percentage, using the peak HR measured during the exercise test;

- **based on the percentage of the peak heart rate** reached during the exercise test;
- **based on subjective perception of exertion**: a Borg score of 12–14 on a scale of 6–20 roughly corresponds to moderate intensity;
- **using the "talk test**": at moderate intensity, the patient can speak in sentences but cannot sing.

In patients treated with beta-blockers, those with atrial fibrillation, or those with cardiac devices, heart rate is a less reliable indicator, and the Borg scale and the talk test become essential tools. Each session includes a **warm-up** period (5–10 minutes), **the** actual **exercise phase**, and a **cool-down** period (5–10 minutes), which are essential for progressive cardiovascular adaptation and for preventing complications.

Progression is gradual, typically beginning with an increase in the duration and frequency of sessions and only then with an increase in intensity, depending on the patient's tolerance and the results of periodic reassessments.

The goal of individualized exercise prescription is not only the physiological effectiveness of the exercise but also the selection of activities that are enjoyable and easy to integrate into the patient's daily routine, since the likelihood of long-term adherence is significantly higher when exercise is perceived as enjoyable, not merely as a therapeutic obligation.

• Types of training used

- **moderate-intensity continuous aerobic training**—the classic, low-risk form, recommended for most patients; performed through walking, stationary cycling, treadmill running, or swimming at a constant intensity;
- **High-intensity interval training (HIIT)**—alternating short periods of intense effort with periods of active recovery; reserved for patients at low to moderate risk, under close supervision, with superior benefits for aerobic capacity;
- **resistance training (muscle strength)**—complements the aerobic component, with beneficial effects on muscle mass, carbohydrate metabolism, and functional autonomy;
- **flexibility and balance exercises**—particularly useful for older patients to prevent falls;
- **respiratory muscle training**—useful for selected patients, particularly those with heart failure and weakness of the inspiratory muscles.

• Classification of aerobic activity by intensity

Typical examples of aerobic activity include brisk walking, jogging, running, cycling, swimming, and other activities that involve large muscle groups. Activity can be classified according to intensity, expressed in metabolic equivalents (METs). One MET corresponds to the oxygen consumption at rest, approximately 3.5 mL O_2/kg/min.

Table 12.b. Classification of aerobic activity by intensity

Intensity	MET	Examples
Light	1.1–2.9	Slow walking, light household chores
Moderate	3–5.9	brisk walking, slow cycling, gardening, dancing
Intense	≥ 6	running, fast cycling, intense swimming, singles tennis

A practical guideline, particularly useful in Phase III of the program, when direct supervision is limited: during moderate-intensity activity, the patient breathes more rapidly but can still speak in complete sentences; during intense activity, conversation becomes difficult. It is also worth noting that, according to current evidence, even activity sessions shorter than 10 minutes, accumulated throughout the day, can have beneficial effects on cardiovascular risk.

Knowing the MET values of various activities is also useful for making recommendations regarding the resumption of daily, occupational, and recreational activities: the exercise capacity determined during an exercise test (expressed in METs) can be compared to the energy requirements of the activity the patient wishes to resume.

• Resistance exercises

Strength training should be combined with aerobic exercise; the guidelines recommend performing it at least two days per week (Class I, Level B). For most adults, the general recommendation is 1–3 sets of 8–12 repetitions, at an intensity of 60–80% of one-repetition maximum, for approximately 8–10 exercises targeting the major muscle groups.

For older adults or those who are untrained, resistance training can be started at a lower intensity—approximately 40–50% of one-repetition maximum—with 10–15 repetitions per set, followed by gradual progression as the body adapts. For this group of patients, incorporating balance exercises is important for preventing falls.

A few safety rules are essential: avoid the Valsalva maneuver (straining while holding one's breath), and exhale during the exertion phase; perform movements slowly and in a controlled manner; use resistance bands, light weights, or machines, which are safer than heavy free weights at the beginning of the program. After sternotomy, exercises that engage the upper limbs and chest are introduced gradually, taking into account the sternum's healing period.

• Combating a Sedentary Lifestyle

A sedentary lifestyle is independently associated with increased mortality and an increased risk of chronic diseases, even among people who meet the recommended amount of structured physical activity. For inactive individuals, even about 15 minutes of light activity per day can produce measurable benefits. Simple practical recommendations: break up long periods of sitting every 30–60 minutes, take the stairs instead of the elevator, take short walks, engage in household chores and gardening, and use a pedometer to gradually increase your daily step count.

Practical note: *The practical message conveyed to the patient should not be merely "exercise," but also "sit less and move more often throughout the day"—the two recommendations act on partially different mechanisms and should be communicated as distinct, not interchangeable, goals.*

• Monitoring safety during exercise

The risk of cardiovascular complications during supervised exercise in rehabilitation programs is low, and the benefits far outweigh the risks. Safety, however, depends on proper assessment prior to program enrollment (clinical evaluation, exercise testing, risk stratification) and adherence to the prescribed intensity.

During exercise sessions, monitoring should include heart rate, blood pressure, peripheral oxygen saturation (as appropriate), and subjective perception of exertion, assessed using the Borg scale. In high-risk patients, telemetric electrocardiographic monitoring is also used. Warning signs that require immediate cessation of exercise include the onset of chest pain, severe dyspnea, dizziness, sustained palpitations, or significant changes in blood pressure.

Before each session, the patient's condition is assessed: new symptoms, resting blood pressure and heart rate values; in patients with heart failure, rapid weight gain; and in diabetic patients, blood glucose levels. The session is postponed if signs of instability are present.

Practical note: *The Borg Scale (6–20) remains a simple and reliable tool for patients to self-regulate exercise intensity, and is particularly useful in phases II and III of the program, when direct supervision is less frequent.*

• The Role of the Rehabilitation Team in Promoting Physical Activity

The physical activity component is at the core of the cardiovascular rehabilitation program, and the multidisciplinary team plays an essential role in its proper and safe implementation:

- **the physician** performs the clinical evaluation, exercise testing, and risk stratification; determines the indications and contraindications; and establishes the safe exercise threshold;
- **the physical therapist** develops and implements the individualized training program (aerobic, strength, balance, and flexibility), supervises the sessions, progressively adjusts the parameters, and teaches the patient to self-regulate exercise intensity;
- **The medical assistant** monitors vital signs before, during, and after the session and recognizes warning signs;
- **the psychologist** works with patients experiencing exercise-related anxiety, fear of symptom recurrence, or low motivation;

- **the dietitian** coordinates physical activity recommendations with nutritional intervention, especially for overweight or sarcopenic patients.

Beyond supervised sessions, the rehabilitation team's role is to prepare the patient to maintain physical activity in the long term after completing the program:

- **educating the patient** on the benefits of physical activity, recommended intensity, warning signs, and how to use the Borg scale and the talk test;
- **setting SMART goals** for physical activity at home (for example, "I will walk for 30 minutes, 5 times a week");
- **providing specific recommendations** on the type of activity, tailored to the patient's preferences and capabilities (walking, cycling, swimming, dancing, gardening);
- **encouraging self-monitoring** through activity logs, pedometers, or wearable devices;
- **involving the family** and, where possible, referring the patient to community or telerehabilitation programs;
- **periodically reassessing** exercise capacity and adjusting recommendations over time.

Summary: *Regular physical activity is one of the most effective interventions for reducing cardiovascular risk, with benefits for blood pressure, lipid profile, carbohydrate metabolism, body weight, endothelial function, and mental health, as well as for mortality. Exercise prescriptions are tailored individually, following the FITT-VP principle, based on clinical evaluation and exercise testing, combining aerobic and resistance training with a reduction in sedentary behavior. The rehabilitation team is responsible for implementing the program safely and transforming supervised exercise into a sustainable lifestyle habit.*

4.5. Optimizing Metabolic and Blood Pressure Control in Cardiovascular Prevention

Dyslipidemia, hypertension, and diabetes mellitus are risk factors with a proven causal role in atherosclerotic cardiovascular disease. Unlike behavioral factors, they are quantifiable through measurable parameters (LDL cholesterol, blood pressure, glycated hemoglobin), for which ESC guidelines establish specific therapeutic targets. Their management is based on a combination of lifestyle modifications and pharmacological treatment, and the cardiovascular rehabilitation program contributes to both components: through physical training, nutritional counseling, and education, on the one hand, and through monitoring progress toward targets and alerting the treating physician to the need for intensified treatment, on the other.

For patients with documented atherosclerotic cardiovascular disease—who make up the majority of those in rehabilitation programs and are classified as being at very high risk—the targets are strict, and the e benefit of simultaneously controlling all risk factors is greater than the sum of the benefits of each intervention taken in isolation.

- **Management of Dyslipidemia**

Controlling dyslipidemia is one of the central pillars of secondary prevention. The causal role of LDL cholesterol and other lipoproteins containing apolipoprotein B in the development of atherosclerosis is well established, and lowering LDL cholesterol is associated with a reduction in the risk of cardiovascular events proportional to the magnitude of the reduction. The general principle is "the lower, the better" and "the earlier, the better." Current guidelines set increasingly stringent target levels for LDL cholesterol based on the patient's risk category.

Table 13 . LDL-cholesterol targets based on risk category (ESC/EAS guidelines)

Risk category	LDL-cholesterol target	Reduction from baseline
Very high risk	< 55 mg/dl (< 1.4 mmol/l)	≥ 50%
Very high risk, with a second vascular event within 2 years	< 40 mg/dl (< 1.0 mmol/l) may be considered	≥ 50%
High risk	< 70 mg/dl (< 1.8 mmol/l)	≥ 50%
Moderate risk	< 100 mg/dl (< 2.6 mmol/l)	–
Low risk	< 116 mg/dl (< 3.0 mmol/l)	–

The treatment strategy is phased. Pharmacological treatment (statins, ezetimibe, PCSK9 inhibitors) must be combined with lifestyle changes:

- **a high-intensity statin** at the maximum tolerated dose is the first-line treatment;
- if the target is not met, **ezetimibe** is added;
- for very high-risk patients who do not reach the target with this combination, a **PCSK9 inhibitor** (monoclonal antibody or inclisiran) is added;
- for patients who cannot tolerate statins, the 2025 update to the ESC/EAS guidelines includes **bempedoic acid**.

In patients with elevated triglycerides, diabetes, or obesity, **non-HDL cholesterol** (target below 85 mg/dL for very high risk) and **apolipoprotein B** (target below 65 mg/dL) are useful secondary targets. Lipoprotein (a) should be measured at least once in a patient's lifetime; elevated levels require stricter control of other risk factors.

Lifestyle factors play an important role in lipid control, although in patients at very high risk, they do not replace drug therapy. Reducing saturated and trans fats, increasing fiber intake, losing weight, and engaging in regular physical activity improve the lipid profile. Aerobic exercise primarily affects triglycerides and HDL cholesterol, with a more modest effect on LDL cholesterol.

Relevance to the rehabilitation program: checking the lipid profile at the initial assessment and at the end of the program; identifying patients who do not meet their targets and reporting them to the attending physician; monitoring adherence to lipid-lowering therapy, which often declines in the first few months following the acute event; recognize statin-associated myalgia, which must be distinguished from post-exercise muscle soreness; educate the patient that normal cholesterol levels while on treatment do not mean the treatment can be stopped.

- **Management of Hypertension**

Hypertension is the most common cardiovascular risk factor and a major cause of coronary artery disease, stroke, heart failure, atrial fibrillation, peripheral artery disease, and chronic kidney disease. Optimal blood pressure control significantly reduces the risk of stroke and heart failure. Meta-analyses of intervention studies show that a reduction of approximately 10 mmHg in systolic blood pressure is associated with a decrease of approximately 20% in major cardiovascular events.

The 2024 ESC Guidelines on Elevated Blood Pressure and Hypertension introduced a new classification and stricter targets:

Table 14 . Blood Pressure Categories and Treatment Targets (ESC 2024 Guidelines)

Category / Parameter	**Values**
Non-elevated blood pressure	< 120/70 mmHg
Elevated BP	120–139 / 70–89 mmHg
Hypertension	≥ 140/90 mmHg
Systolic blood pressure target for most treated patients	120–129 mmHg, if well tolerated
Diastolic blood pressure target	70–79 mmHg
Frail elderly patients with orthostatic hypotension or poor tolerance	as low as reasonably possible, individualized

Accurate blood pressure measurement is essential: the patient sits at rest for several minutes, with the arm supported at heart level and a properly sized cuff. Home blood pressure measurements and 24-hour ambulatory monitoring supplement clinic readings and help identify "white coat" hypertension and masked hypertension.

The recovery program helps control blood pressure through regular physical exercise, reducing sodium intake, stress management, and, when appropriate, optimizing antihypertensive treatment in collaboration with the treating physician. Nonpharmacological measures have a proven effect:

- **regular aerobic exercise** reduces systolic blood pressure by a few mmHg, an effect comparable to that of an antihypertensive medication used as monotherapy;

- **reducing salt intake** to less than 5 g/day;
- **weight loss** in overweight patients;
- **limiting alcohol consumption** and following **a diet rich in fruits and vegetables** (e.g., the DASH diet);
- **treating obstructive sleep apnea**, which is common in patients with hypertension and obesity.

Pharmacological treatment is based, in most patients, on combinations of medications (angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, calcium channel blockers, thiazide or thiazide-like diuretics), preferably in fixed-dose combinations in a single tablet to improve adherence.
Relevance to the rehabilitation program: measuring blood pressure before, during, and after each session; postponing the session if resting blood pressure is very high; identifying an exaggerated blood pressure response to exercise and post-exercise hypotension, which is common in patients treated with multiple antihypertensive medications; recognizing orthostatic hypotension in the elderly; educating the patient on how to correctly self-monitor blood pressure at home; avoiding the Valsalva maneuver during resistance exercises.

- **Management of Diabetes Mellitus**

Diabetes accelerates the atherosclerotic process in all vascular territories and approximately doubles the risk of atherosclerotic cardiovascular disease. Diabetic patients frequently have diffuse coronary artery disease, involvement of multiple vascular territories, and silent ischemia. In patients with diabetes mellitus associated with cardiovascular disease, glycemic control must be integrated into a comprehensive approach that simultaneously includes lipid, blood pressure, and weight control.

Table 15 . Primary therapeutic goals in patients with diabetes and cardiovascular disease

Parameter	**Target**
Glycated hemoglobin (HbA1c)	< 7% in most patients; a less stringent target in the elderly, frail patients, or those at high risk of hypoglycemia
LDL cholesterol	< 55 mg/dl and a reduction of ≥ 50% (very high risk)
Blood pressure	Systolic blood pressure 120–129 mmHg, if tolerated
Cardiovascular-beneficial therapy	SGLT2 inhibitors and/or GLP-1 receptor agonists in patients with type 2 diabetes and atherosclerotic cardiovascular disease, regardless of glycemic control
Body weight	Weight loss in overweight or obese patients

An important aspect of the 2023 ESC guidelines on cardiovascular disease in patients with diabetes is that the choice of antidiabetic treatment is no longer based solely on glycemic control: In patients with type 2 diabetes and atherosclerotic cardiovascular disease, SGLT2 inhibitors and GLP-1 receptor agonists with demonstrated cardiovascular benefits are recommended to reduce cardiovascular events, regardless of HbA1c levels. SGLT2 inhibitors also have beneficial effects in heart failure and chronic kidney disease.
The rehabilitation program should include education on glycemic self-management, dietary adjustments, and tailoring physical activity based on the risk of hypoglycemia, particularly in patients receiving insulin or sulfonylurea therapy. Regular physical activity increases insulin sensitivity and improves glycemic control, and combining aerobic and resistance training yields the most favorable results.
Several practical precautions are essential for diabetic patients enrolled in the program:

- **checking blood glucose levels before the session** in patients treated with insulin or sulfonylureas; if levels are low, a carbohydrate snack is recommended before exercise, and if levels are very high—especially in the presence of ketones—exercise should be postponed;
- **recognizing the symptoms of hypoglycemia** (sweating, tremors, palpitations, confusion, weakness) and ensuring a source of rapidly absorbed glucose is available in the recovery room;

- **be aware of delayed hypoglycemia**, which can occur several hours after exercise, including at night;
- **be alert for silent ischemia**: the absence of angina does not rule out myocardial ischemia, and ECG changes and atypical symptoms (shortness of breath, unusual fatigue) should be closely monitored;
- **foot examinations** and appropriate footwear for patients with peripheral neuropathy, to prevent injuries;
- **Adapt exercise** to diabetic complications: avoid intense exertion that causes large increases in blood pressure in patients with proliferative retinopathy; exercise caution in patients with autonomic neuropathy (abnormal heart rate and blood pressure responses to exertion).

Relevance to the rehabilitation program: checking HbA1c levels and antidiabetic treatment during the initial assessment; educating the patient on self-monitoring of blood glucose and adjusting their diet on days involving exercise; collaborating with the endocrinologist to adjust insulin or sulfonylurea doses as the volume of physical activity increases.

- **Integrated Approach to Risk Factors**

Dyslipidemia, hypertension, and diabetes mellitus frequently coexist, often in the context of abdominal obesity and metabolic syndrome, and they reinforce one another. For this reason, their management should not be approached in isolation but through a comprehensive strategy, in which the same lifestyle interventions (physical activity, diet, weight loss, smoking cessation) simultaneously address all of these factors. In patients at very high risk, simultaneously achieving all therapeutic targets results in the greatest reduction in the risk of recurrent events.

Table 16 . Summary of therapeutic targets for patients with atherosclerotic cardiovascular disease (very high risk)

Risk factor	**Target**
LDL cholesterol	< 55 mg/dl and a reduction of ≥ 50%
Non-HDL cholesterol / ApoB	< 85 mg/dl / < 65 mg/dl
Blood pressure	Systolic 120–129 mmHg, diastolic 70–79 mmHg, if tolerated
Diabetes	HbA1c < 7% (individualized); SGLT2i and/or GLP-1 RA with cardiovascular benefit
Weight	BMI 20–25 kg/m², waist circumference < 94 cm (men) / < 80 cm (women)
Smoking	Complete cessation
Physical activity	150–300 min/week of moderate-intensity exercise + strength training 2 times/week

- **The role of the rehabilitation team in managing metabolic and hemodynamic risk factors**

The rehabilitation program provides an ideal framework for monitoring and optimizing the management of these risk factors, thanks to repeated contact with the patient. The team's role includes:

- **during the initial assessment**: documenting baseline values (lipid profile, blood pressure, HbA1c, weight, waist circumference) and setting individual goals, explicitly noted in the patient's chart;
- **during the program**: monitoring blood pressure at each session, blood glucose levels in diabetic patients treated with insulin or sulfonylureas, and body weight; verifying adherence to treatment;
- **lifestyle intervention**: tailored physical training, nutritional counseling, and stress management;

- **collaboration with the attending physician**: reporting situations where targets are not met or where adverse effects of treatment occur (hypotension, hypoglycemia, myalgia), to adjust therapy;
- **patient education**: understanding treatment goals, self-monitoring at home, and the importance of continuing treatment over the long term;
- **At the end of the program**: reassessment of parameters, comparison with baseline values, and submission of a follow-up plan to the treating physician and the primary care physician.

Practical Note: *For patients in the rehabilitation program, the key question is not only "Are they exercising correctly?" but also "Have they achieved their targets for LDL cholesterol, blood pressure, and blood glucose?" The rehabilitation team is often the first to notice that these targets are not being met and has a responsibility to report this.*

Summary: *Controlling dyslipidemia, hypertension, and diabetes is essential for reducing cardiovascular risk, particularly in very high-risk patients. The ESC guidelines establish specific targets for each factor, achieved through a combination of lifestyle modifications and pharmacological treatment. The rehabilitation program contributes directly through physical training, nutritional counseling, and education, and indirectly through monitoring target achievement and collaborating with the attending physician to optimize treatment.*

4.6. Management of Psychosocial Factors

Psychosocial factors are recognized, alongside classic risk factors, as important determinants of the onset and progression of cardiovascular disease. They influence risk both directly, through biological mechanisms, and indirectly, through risk behaviors and treatment adherence. The 2021 ESC Guidelines on Cardiovascular Prevention place particular emphasis on these factors and recommend their assessment and management as an integral part of prevention.

The main psychosocial factors associated with an increased cardiovascular risk and a poorer prognosis are:

- **low socioeconomic status** (low level of education, low income, unemployment);
- **social isolation** and lack of social support;
- **chronic stress**, whether work-related or family-related;
- **depression** and **anxiety**;
- **hostility and anger**, as well as **Type D** personality (a tendency to experience negative emotions and suppress them in social relationships);
- **post-traumatic stress disorder**, which can also occur after an acute cardiovascular event or following a shock from an implantable defibrillator.

- **Stress, Anxiety, and Depression in the Cardiovascular Context**

Anxiety and depression are common in patients with cardiovascular disease, both as a reaction to the acute event and as independent risk factors for poor outcomes. depressive symptoms are present in a significant proportion of patients after a myocardial infarction, and major depression affects, according to various estimates, approximately one in five patients. Post-myocardial infarction depression, in particular, is associated with poor treatment adherence, reduced participation in rehabilitation programs, and an increased risk of mortality.

Anxiety frequently occurs in the first few weeks following the acute event and manifests as fear of symptom recurrence, fear of exertion, hypervigilance regarding bodily sensations (palpitations, chest pains), and avoidance of physical activities. This fear of exertion, sometimes called **kinesophobia**, can significantly limit participation in the rehabilitation program and the resumption of daily activities. In patients with an implantable defibrillator, fear of shock is a common source of anxiety.

The relationship between psychological factors and cardiovascular disease can be explained by several mechanisms:

- **biological mechanisms**: activation of the hypothalamic-pituitary-adrenal axis, with increased cortisol; increased sympathetic tone, heart rate, and blood pressure; decreased heart rate variability, with an increased risk of arrhythmias; systemic inflammation; endothelial dysfunction; increased platelet aggregability;

- **behavioral factors**: smoking, a sedentary lifestyle, unhealthy diet, alcohol consumption, sleep disorders, and poor adherence to treatment and medical recommendations.

Symptoms of depression can sometimes be difficult to distinguish from those of cardiovascular disease: fatigue, lack of energy, sleep disturbances, and decreased exercise tolerance can stem from either condition. For this reason, active screening is essential.

- **Assessment and Screening for Psychosocial Factors**

Identifying psychosocial factors should be part of the initial assessment of every patient enrolled in the rehabilitation program. This can be accomplished through a few simple questions during the medical history interview, supplemented by standardized, brief, and easy-to-administer questionnaires:

Table 17 . Screening Tools for Psychosocial Factors

Tool	Use
PHQ-2 and PHQ-9	Screening for depression; PHQ-2 (two questions) as a first step, followed by PHQ-9 (nine questions) if the result is positive
GAD-7	Screening for generalized anxiety
HADS	Hospital Anxiety and Depression Scale, adapted for patients with somatic illnesses
Questions about social support	Who does the patient live with, who can help them, and do they feel lonely?
Questions about stress	Stress at work, financial difficulties, family problems

The two questions on the PHQ-2 are simple and can be asked by any team member: “In the past two weeks, how often have you felt a lack of interest or pleasure in the things you do?” and “In the past two weeks, how often have you felt sad, depressed, or hopeless?”

Practical note: *The presence of thoughts of suicide or self-harm is a red flag that requires urgent psychiatric evaluation. Any team member who identifies such signs must immediately inform the coordinating physician.*

- **The Interdependence of Cardiovascular and Mental Health**

Cardiovascular and mental health are closely interdependent. Quitting smoking, regular exercise, and a healthy diet can simultaneously reduce cardiovascular risk and alleviate mental health symptoms through both physiological and behavioral mechanisms. However, patients with mental health conditions often have lower adherence to lifestyle changes and medication, which is why they require additional, structured support from the recovery team.

Physical exercise has a proven antidepressant and anxiolytic effect, and the recovery program itself reduces symptoms of anxiety and depression. The repeated experience of safely tolerating physical exertion under supervision helps patients regain confidence in their own bodies and overcome their fear of exertion. Participation in group programs also provides social interaction and mutual support among patients with similar experiences.

The relationship is bidirectional: patients with severe mental disorders (schizophrenia, bipolar disorder, major depression) also have an increased cardiovascular risk due to an unhealthy lifestyle, the metabolic effects of certain psychotropic medications, and reduced access to medical services. In these patients, the assessment and management of cardiovascular risk factors must be carried out with particular care.

- **Psychosocial interventions**

For patients with atherosclerotic cardiovascular disease and associated mental disorders, the guidelines recommend evidence-based care and interdisciplinary collaboration (Class I, Level B). Stress management through psychotherapy may be considered for patients with cardiovascular disease and significant psychological stress (Class IIa, Level B). Psychological interventions and

stress management techniques can contribute both to alleviating psychological symptoms and to reducing cardiovascular recurrences in some patients.

Interventions are applied gradually, depending on the severity of symptoms:

- **basic education and counseling**, provided to all patients: explaining that emotional reactions following a cardiac event are common and normal, providing information about the disease, the safety of physical activity, and the prospects for recovery;
- **stress management techniques**: relaxation techniques, controlled breathing, progressive muscle relaxation, mindfulness, time management, and identifying sources of stress;
- **psychotherapy**, particularly cognitive-behavioral therapy, which helps patients identify and modify dysfunctional thoughts and behaviors related to the disease;
- **medication**, for patients with moderate to severe depression or anxiety, prescribed by a psychiatrist or the patient's primary care physician; selective serotonin reuptake inhibitors (e.g., sertraline) are considered safe for patients with coronary artery disease, while tricyclic antidepressants should be avoided due to adverse cardiovascular effects.

Psychosocial interventions are more effective when integrated into the recovery program—rather than offered separately—and when combined with physical exercise and health education.

- **Social Support and Reintegration**

Adequate social support, family involvement in the recovery process, and gradual reintegration into professional and social activities significantly contribute to maintaining the patient's motivation and long-term adherence to the prevention program. Social isolation and loneliness are independently associated with a poorer cardiovascular prognosis.

The family plays an important role, but overprotection should be avoided, as it can reinforce the patient's fear of exertion and dependence. The partner and family should be informed about the disease, the safety of physical activity, and warning signs, so they can support the patient without unnecessarily limiting their autonomy.

Reintegration involves several practical aspects about which patients are often uncertain and which must be actively addressed:

- **returning to work**, based on the exercise capacity determined by the stress test and the physical and mental demands of the job;
- **resuming driving**, in accordance with medical recommendations and applicable regulations;
- **resuming sexual activity**, a topic often avoided but important for quality of life; in general, a stable patient who can perform moderate exertion (e.g., climbing two flights of stairs without symptoms) may resume sexual activity; it is important to note the contraindication against combining nitrates with phosphodiesterase-5 inhibitors;
- **resuming recreational activities and travel**.

The rehabilitation team should collaborate, when necessary, with a clinical psychologist or psychiatrist for cases with significant symptoms.

- **The Role of the Rehabilitation Team in Managing Psychosocial Factors**

Each member of the recovery team plays a role in identifying and managing psychosocial factors:

- **the physician** conducts screening during the initial assessment, determines the need for specialized evaluation, and coordinates collaboration with the psychologist and psychiatrist;
- **the clinical psychologist** conducts a detailed assessment, provides stress management interventions, and offers psychotherapy, either individually or in a group setting;
- **the physical therapist**, who is in direct and frequent contact with the patient, is often the first to notice signs of anxiety, fear of exertion, lack of motivation, or repeated absences; through gradual, safe exposure to physical exertion, the physical therapist directly contributes to reducing kinesophobia and helping the patient regain confidence;
- **the medical assistant** observes the patient's emotional state at each session and reports any changes to the team.

In practice, addressing psychosocial factors in the rehabilitation program involves:

- **systematic screening** for depression, anxiety, and social support during the initial assessment and reevaluation at the end of the program;
- **empathetic communication** that encourages the patient to talk about their fears and difficulties;
- **educating the patient and family** about emotional reactions following a cardiac event and about safe levels of physical exertion;
- **the integration of relaxation** and controlled breathing **techniques** into rehabilitation sessions;
- **referral for specialized evaluation** of patients with moderate or severe symptoms;
- **support for social and professional reintegration**.

Practical Note: *A patient who repeatedly misses sessions, appears listless, or avoids increasing the intensity of exercise is not necessarily "unmotivated": these behaviors may mask depression or anxiety. Recognizing them and addressing them with empathy can change the patient's progress in the program.*

Summary: *Psychosocial factors—particularly depression, anxiety, chronic stress, and social isolation—significantly influence cardiovascular risk, treatment adherence, and participation in the rehabilitation program. Systematic screening, graduated interventions (ranging from education and relaxation techniques to psychotherapy and medication), family involvement, and support for reintegration are integral parts of the recovery program. Interdisciplinary collaboration, involving a psychologist and, when necessary, a psychiatrist, is essential for patients with significant symptoms.*

4.7. Summary of Practical Recommendations on Lifestyle Interventions

The following table summarizes the main quantitative targets of non-pharmacological interventions, serving as a quick reference for members of the cardiovascular rehabilitation team in their clinical practice.

Table 18 . Summary of Targets for Lifestyle Interventions

Intervention	Main Target / Recommendation
Aerobic activity	150–300 min/week of moderate-intensity or 75–150 min/week of vigorous-intensity
Strength training	≥ 2 days per week
Sedentary lifestyle	Reduction and periodic breaks through physical activity
Diet	Mediterranean-style diet
Salt	< 5 g/day
Fiber	30–45 g/day
Fruit	≥ 200 g/day
Vegetables	≥ 200 g/day
Fish	1–2 times/week
Nuts	~30 g/day
Red meat	≤ 350–500 g/week
Processed meat	as little as possible
Sugar	< 10% of total energy intake
Alcohol	≤ 100 g of pure alcohol per week
Overweight/obesity	Weight loss; even 5–10% is beneficial
Smoking	complete cessation
Mental health	Screening, support, and interdisciplinary intervention, when necessary

Lifestyle modification is the foundation of cardiovascular prevention, regardless of risk category and regardless of whether the patient subsequently receives pharmacological treatment. Regular physical activity, reducing sedentary behavior, a Mediterranean-style diet, weight control, mental health, and complete smoking cessation together form an integrated strategy for reducing cardiovascular risk.

Practical Note: *The intervention must be individualized and implemented gradually, with realistic goals and the patient's active involvement. The effectiveness of prevention depends not only on choosing a clinically sound recommendation but also on the patient's actual ability to adopt and maintain it over the long term.*

5. CARDIOVASCULAR REHABILITATION - FROM PREVENTION RECOMMENDATIONS TO CLINICAL PRACTICE

- **The Interrelationship Between Prevention and Cardiovascular Rehabilitation**

Prevention and cardiovascular rehabilitation are not separate stages of care, but two components of the same process that build upon one another. Prevention aims to avoid the onset of cardiovascular disease or its recurrence by controlling risk factors. Rehabilitation occurs following an acute cardiovascular event, after revascularization, or in the presence of chronic cardiovascular disease. It aims to restore functional capacity and reduce the risk of future events. For this reason, cardiovascular rehabilitation is now considered the most comprehensive and effective form of secondary prevention.

The relationship between the two works both ways. On the one hand, prevention provides rehabilitation with therapeutic goals and targets, as outlined in current guidelines: smoking cessation, regular physical activity, a healthy diet, optimal weight, target levels for LDL cholesterol, blood pressure, and blood glucose, as well as adherence to cardioprotective treatment. On the other hand, rehabilitation provides prevention with the practical framework within which these targets can be achieved. Through individual assessment, supervised physical training, therapeutic education, nutritional and psychological counseling, and treatment optimization, general recommendations become concrete interventions, tailored to each patient and monitored over time.

This connection continues even after the structured rehabilitation program ends. The maintenance phase (Phase III) is, in essence, long-term prevention. The patient independently applies the habits formed during the program, with the support of the cardiologist and the primary care physician. Thus, cardiovascular rehabilitation marks the transition from treating an acute event to ongoing prevention, and its benefits are sustained only if the principles of prevention are followed throughout one's life. For the rehabilitation team, every rehabilitation session is therefore also an act of prevention, and every prevention goal achieved is a measure of the rehabilitation's success.

Cardiovascular prevention guidelines set clear targets for each risk factor: complete cessation of smoking, regular physical activity, a healthy diet, optimal body weight, target levels for LDL cholesterol, blood pressure, and blood glucose, as well as adherence to cardioprotective treatment. However, there is a significant gap between the guidelines' recommendations and clinical reality. European observational studies (such as the EUROASPIRE registries) have repeatedly shown that, following a coronary event, a significant proportion of patients continue to smoke, are sedentary, are overweight or obese, and do not meet the recommended lipid, blood pressure, and blood glucose targets.

This gap between "what we know" and "what we do" is not due to a lack of information, but rather to the difficulty of translating recommendations into lasting behavioral changes and optimized long-term treatment. Cardiovascular rehabilitation provides the organized framework within which this transformation becomes possible: a structured, multidisciplinary, and individualized program in which each preventive recommendation is assessed, implemented, monitored, and adjusted over time.

Cardiovascular rehabilitation is defined as a coordinated set of interventions aimed at restoring the cardiovascular patient's optimal physical, mental, and social functioning, stabilizing or slowing the progression of the disease, and reducing the risk of future events. In its current understanding, cardiovascular rehabilitation is not limited to physical training but is a **comprehensive secondary prevention program** that integrates medical evaluation, physical training, physical activity counseling, nutritional intervention, weight control, lipid management, blood pressure and blood glucose control, smoking cessation, management of psychosocial factors, and therapeutic education.

The specific role of rehabilitation is to transform each general prevention recommendation into a concrete, individualized, and verifiable intervention. The table below summarizes how the main prevention recommendations are applied within the rehabilitation program.

Table 19 . Application of Prevention Recommendations in the Cardiovascular Rehabilitation Program

Area	Guideline Recommendation	Application in Rehabilitation
Physical activity	150–300 min/week of moderate-intensity exercise or 75–150 min of vigorous-intensity exercise; strength training ≥2 days/week	Exercise testing, individualized prescription (FITT-VP), supervised training, gradual progression, plan for home exercise
Smoking	Complete cessation of all forms of tobacco use	Status assessment, counseling (5A), pharmacological treatment, behavioral support, monitoring at each session
Diet	Mediterranean-style diet, salt <5 g/day, reduction of saturated fats	Nutritional assessment, individual and group counseling, personalized meal plan, family involvement
Weight	BMI 20–25 kg/m², waist circumference within recommended limits	Periodic anthropometric measurements, realistic weight loss goals, combining diet with physical activity
Lipids	LDL-C <55 mg/dl and ≥50% reduction in patients at very high risk	Check lipid profile, report unmet targets, have the doctor intensify treatment, provide education on adherence
Blood pressure	Systolic target 120–129 mmHg, if tolerated	Measure BP at every visit, provide education on self-monitoring, adjust treatment, consider the blood-pressure-lowering effect of exercise
Diabetes	HbA1c <7%, treatment with proven cardiovascular benefits	Monitoring blood glucose levels before and after exercise, preventing hypoglycemia, collaboration with the endocrinologist
Psychosocial factors	Screening and management of stress, anxiety, and depression	Screening questionnaires, psychological counseling, relaxation techniques, support for reintegration
Cardioprotective treatment	Optimal medication according to guidelines, long-term adherence	Review of the treatment plan, dose titration, education on the role of each medication

Thus, cardiovascular rehabilitation is a process where the patient not only receives recommendations but also learns to apply them, is monitored while doing so, and receives adjustments when the results are not as desired.

- **The Role of Cardiovascular Rehabilitation in Prevention**

The role of rehabilitation in implementing prevention can be described on several levels:

- **assessment role**—risk stratification, evaluation of functional capacity through exercise testing, identification of all risk factors and comorbidities, as well as assessment of psychosocial status;
- **therapeutic role**—individualized physical training that simultaneously addresses multiple risk factors (blood pressure, lipid profile, blood glucose, weight, stress);
- **treatment optimization role** – frequent contact with the patient allows for monitoring therapeutic goals, adjusting medication, and identifying adverse effects;
- **educational role** – the patient understands the disease, risk factors, warning signs, and the importance of treatment, becoming an active partner in care;
- **behavioral role**—recovery provides the time and support needed to form new habits (diet, exercise, quitting smoking) through repeated counseling and progressive goals;

- **psychosocial role** – reducing anxiety and fear of physical exertion, regaining confidence in one's own abilities, and providing support for a return to family life, work, and society;
- **continuity of care role** – rehabilitation bridges the gap between the hospital, the cardiologist, and the primary care physician, ensuring a long-term prevention plan after the program ends.

A major advantage of rehabilitation is its **comprehensive and simultaneous** approach to risk factors. Unlike a routine consultation, where limited time often allows only for medication adjustments, the rehabilitation program offers repeated contact, time for education, and a team that addresses every component of cardiovascular risk.

- **Benefits of Cardiovascular Rehabilitation**

The benefits of cardiovascular rehabilitation have been demonstrated by numerous randomized trials and meta-analyses and manifest on multiple levels.

Prognostic benefits. Participation in exercise-based cardiovascular rehabilitation is associated with reduced cardiovascular mortality, reduced risk of recurrent myocardial infarction, and fewer readmissions. In patients with heart failure, rehabilitation reduces hospitalizations—particularly those caused by worsening heart failure—and improves quality of life.

Functional benefits. Physical training increases exercise capacity (peak VO2, distance on the 6-minute walk test, exercise tolerance), improves muscle strength and endurance, balance, and independence in daily activities. Increased functional capacity has prognostic value in its own right, as exercise capacity is one of the strongest predictors of survival.

Benefits Regarding Risk Factors. The rehabilitation program helps lower blood pressure, improve the lipid profile (particularly by increasing HDL cholesterol and lowering triglycerides), increase insulin sensitivity and improve glycemic control, reduce body weight and waist circumference, and increase smoking cessation rates.

Direct cardiovascular benefits. Regular physical exercise improves endothelial function, reduces systemic inflammation, improves autonomic balance (lowers resting heart rate, increases heart rate variability), and lowers the ischemic threshold, allowing the patient to engage in more intense activities without symptoms.

Psychosocial benefits. Rehabilitation reduces symptoms of anxiety and depression, increases the patient's confidence in their own body, and improves quality of life. Patients who participate in the program return to work and social activities more frequently and more quickly.

Benefits for adherence. Patients who participate in rehabilitation show better adherence to medication and the recommended lifestyle, which extends the preventive benefits long after the program ends.

Benefits for the healthcare system. By reducing readmissions and recurrent events, cardiovascular rehabilitation is a cost-effective intervention.

Table 20 . Benefits of Cardiovascular Rehabilitation – Summary

Area	Main Benefits
Prognosis	Reduction in cardiovascular mortality, recurrent heart attacks, and readmissions
Functional capacity	Increased peak VO2 and exercise tolerance, improved muscle strength and independence
Risk Factors	Lower blood pressure, improved lipid and glycemic profiles, weight loss, smoking cessation
Cardiovascular mechanisms	Improved endothelial function, anti-inflammatory effect, better autonomic balance, increased ischemic threshold
Psychosocial	Reduced anxiety and depression, improved quality of life, social and professional reintegration
Adherence and healthcare system	Increased treatment adherence, cost-effectiveness, cost reduction by avoiding hospitalizations

- **Underutilization of Cardiovascular Rehabilitation—A Clinical Practice Issue**

Despite a high level of evidence, cardiovascular rehabilitation remains underutilized. In many European countries, only a minority of eligible patients participate in a rehabilitation program, and participation is lower among women, older adults, patients with multiple comorbidities, those with low socioeconomic status, and those living in rural areas. There are multiple causes: lack of a referral upon discharge, a limited number of centers, distance from the center, costs, lack of time, and low patient motivation.

To increase access, current guidelines recommend:

- **systematic referral** of all eligible patients upon discharge;
- **home-based and hybrid programs**, which can be considered to increase long-term participation and adherence to healthy behaviors;
- **telerehabilitation and digital health** (remote monitoring, apps, video consultations), as an alternative to or supplement for traditional programs;
- **tailoring the program** to the needs of elderly, frail, or patients with multiple comorbidities.

- **The Role of the Rehabilitation Team**

Prevention through rehabilitation is possible only through the work of a multidisciplinary team, in which each member has a well-defined role:

- **cardiologist/rehabilitation physician**—assesses and stratifies risk, interprets exercise testing, establishes indications and contraindications, optimizes treatment, and monitors progress toward therapeutic goals;
- **physical therapist** – implements the exercise prescription, supervises sessions, monitors response to exercise and warning signs, gradually increases intensity, and educates the patient on performing physical exercise at home;
- **the medical assistant** – monitors vital signs, checks treatment adherence, and participates in therapeutic education and smoking cessation counseling;
- **nutritionist/dietitian** – conducts nutritional assessments and counseling and develops personalized meal plans;
- **Psychologist** – screens for and manages stress, anxiety, and depression, and supports behavioral change;
- **the family physician** – takes over continuity of care after the program ends and maintains long-term control of risk factors.

The patient and their family are active members of the team. The program's success depends largely on their involvement and their commitment to taking responsibility for their own health.

Practical Note: *For the physical therapist, each rehabilitation session is an opportunity for prevention, not just physical training. Measuring blood pressure, asking about smoking, observing emotional state, verifying medication adherence, and encouraging healthy eating transform the exercise session into a comprehensive secondary prevention intervention.*

Summary: *Cardiovascular rehabilitation serves as the bridge between the recommendations of prevention guidelines and their actual application to the patient. As a comprehensive, multidisciplinary, and individualized program—with a Class I recommendation in the ESC guidelines—rehabilitation reduces cardiovascular mortality and readmissions, increases functional capacity and quality of life, and improves risk factor control and treatment adherence. Its underutilization remains a major challenge, and systematic referrals and alternative models (home-based, hybrid, and telerehabilitation) are essential solutions for increasing access.*

ABBREVIATIONS

Table 21 . Glossary of Abbreviations – Chapter I

Abbreviation	Meaning
5A	Ask, Advise, Assess, Assist, Arrange (a counseling model for smoking cessation)
ACC	American College of Cardiology
AHA	American Heart Association
ApoB	Apolipoprotein B
CVD	Cardiovascular diseases
COPD	Chronic obstructive pulmonary disease
DASH	Dietary Approaches to Stop Hypertension
EAPC	European Association of Preventive Cardiology
EAS	European Atherosclerosis Society
ECG	Electrocardiogram
ESC	European Society of Cardiology
EUROASPIRE	European Action on Secondary and Primary Prevention by Intervention to Reduce Events – European registry for secondary and primary prevention
HR	Heart rate
FITT-VP	Frequency, Intensity, Time, Type, Volume, Progression – exercise prescription parameters
GAD-7	Generalized Anxiety Disorder-7 – screening questionnaire for generalized anxiety (7 questions)
GFR	Glomerular filtration rate
GIP	Glucose-Dependent Insulinotropic Polypeptide
GLP-1 RA	Glucagon-Like Peptide-1 Receptor Agonist – glucagon-like peptide-1 receptor agonist
HADS	Hospital Anxiety and Depression Scale
HbA1c	Glycated hemoglobin
HBP	High blood pressure
HDL-C	High-Density Lipoprotein Cholesterol
HIIT	High-Intensity Interval Training
HIV	Human Immunodeficiency Virus
BMI	Body Mass Index
INR	International Normalized Ratio
LDL-C	Low-Density Lipoprotein Cholesterol – LDL cholesterol
LIFE-CVD	LIFEtime-perspective CardioVascular Disease – a model for estimating lifetime cardiovascular risk
Lp(a)	Lipoprotein (a)
MEDAS	Mediterranean Diet Adherence Screener – questionnaire on adherence to the Mediterranean diet (14 questions)
MET	Metabolic Equivalent of Task – metabolic equivalent
non-HDL-C	Non-HDL cholesterol (total cholesterol minus HDL cholesterol)
OARS	Open questions, Affirmations, Reflective listening, Summarizing (motivation-enhancing interview techniques)
WHO	World Health Organization
PCSK9	Proprotein Convertase Subtilisin/Kexin type 9

Abbreviation	Meaning
PHQ-2 / PHQ-9	Patient Health Questionnaire-2 / -9 – screening questionnaire for depression (2 / 9 questions)
PM2.5	Fine particulate matter with a diameter of ≤ 2.5 µm
PREDIMED	PREvención con DIeta MEDiterránea – a study on prevention through the Mediterranean diet
SCORE	Systematic Coronary Risk Evaluation – systematic evaluation of coronary risk
SCORE2	Algorithm for estimating 10-year cardiovascular risk (ages 40–69)
SCORE2-Diabetes	Algorithm for estimating 10-year cardiovascular risk in patients with type 2 diabetes
SCORE2-OP	SCORE2-Older Persons – algorithm for estimating cardiovascular risk in individuals aged ≥ 70 years
SGLT2i	Sodium-Glucose Cotransporter-2 inhibitors
SMART (model)	Second Manifestations of ARTerial disease – a model for estimating the risk of recurrent events
SMART (goals)	Specific, Measurable, Achievable, Relevant, Time-bound – specific, measurable, achievable, relevant, time-bound objectives
BP	Blood pressure
VO2	Oxygen consumption
VT1, VT2	Ventilatory Threshold 1, 2 – first and second ventilatory thresholds

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CHAPTER II. CARDIOVASCULAR REHABILITATION PROTOCOLS FOR COMPLEX CASES

Laura Crăciun

1. INTRODUCTION

- **Definition of Cardiovascular Rehabilitation**

Cardiovascular rehabilitation is defined by the European Society of Cardiology and the European Association for Preventive Cardiology (EAPC) as a complex, structured, and multidisciplinary intervention that combines a thorough clinical evaluation, individualized exercise prescription, active management of cardiovascular risk factors, patient education, and psychosocial support, with the stated goal of optimizing the physical, functional, and mental well-being of patients with cardiovascular disease and reducing the risk of recurrence of major cardiovascular events.

This seemingly simple definition masks a significant paradigm shift from the traditional perception of rehabilitation as being synonymous exclusively with supervised physical training. In reality, while the exercise component is central and highly visible, it represents only one of the pillars of a comprehensive program, alongside risk factor management, patient education, and mental health interventions.

- **Goals of Cardiovascular Rehabilitation**

The goals of a cardiovascular rehabilitation program can be grouped, for educational purposes, into three main categories:

- physiological and functional goals: improving aerobic capacity, muscle strength, balance, and overall functional autonomy;
- cardiovascular risk-related goals: controlling modifiable risk factors, reducing the risk of recurrent events, and slowing the progression of atherosclerosis;
- psychosocial and quality-of-life goals: improving anxiety and depression symptoms, increasing the patient's confidence in their own physical abilities, and facilitating social and professional reintegration.

The relative weight of these goals varies depending on the patient's profile: for a young patient who has had an uncomplicated myocardial infarction, the emphasis may be on rapid professional reintegration and aggressive secondary prevention, whereas for an elderly patient with advanced heart failure, the central objective may be maintaining functional autonomy and preventing readmissions—a topic discussed in detail in the chapters dedicated to complex cases.

- **Cardiovascular rehabilitation—a complex intervention, not just physical training**

Cardiovascular rehabilitation should not be viewed as an administrative, optional step following the "actual" treatment of heart disease, but rather as a therapeutic component in its own right, with a Class I recommendation in most relevant ESC guidelines for stable coronary artery disease, acute coronary syndrome, chronic heart failure, and—with the adaptations discussed in this volume—it also applies to numerous other categories of cardiovascular patients: those who have undergone cardiac surgery or percutaneous valve interventions, those with implantable devices (CRT, ICD, LVAD), those who have undergone heart transplantation, or those with peripheral arterial disease.

According to the position statement of the EAPC (*European Association of Preventive Cardiology*), modern cardiovascular rehabilitation is a **complex multidisciplinary intervention**, and physical training is just one of **its components**:

- initial clinical assessment and risk stratification;
- individualized physical training and counseling on physical activity;
- control of risk factors: blood pressure, lipid profile, diabetes, body weight, smoking;
- nutritional counseling;
- optimization of and adherence to pharmacological treatment;
- patient education for self-management of the disease;
- psychosocial assessment and support;

- support for professional and social reintegration.

The role of recovery extends far beyond the immediate post-event period.
A well-structured program fulfills several functions simultaneously:

1. Direct therapeutic role. Physical training improves functional capacity, endothelial function, muscle metabolism, and, in some patients, ventricular remodeling. It thus has effects comparable to those of drug therapy.
2. A starting point for long-term secondary prevention. The period following an acute event is when the patient is most receptive to lifestyle changes. The program transforms this "window of opportunity" into lasting habits: regular physical activity, a healthy diet, and smoking cessation.
3. Optimization of pharmacological treatment. Regular contact with the medical team allows for monitoring adherence, identifying adverse effects, and titrating treatment to the doses recommended by guidelines. This is particularly important in heart failure, where fundamental medical therapy (FMT) is often underdosed.
4. Intensive patient education. Patients learn to understand their condition, recognize warning signs, self-monitor their weight, blood pressure, and symptoms, and properly manage their treatment. The goal is to transition from the role of a passive patient to that of an active partner in care.
5. Early identification of complications. Regular monitoring, 2–3 times a week, allows for the early recognition of signs of heart failure decompensation, residual ischemia, arrhythmias, or adverse drug reactions. This enables intervention before readmission.
6. Psychological support. Anxiety and depression following a cardiac event are common and are associated with a poorer prognosis. The program provides a safe environment in which patients regain confidence in their own bodies and their ability to exercise, and it allows for the identification of patients who require specialized psychological evaluation.
7. Social and occupational reintegration. An objective assessment of exercise capacity allows for concrete recommendations regarding the resumption of work, driving, sexual activity, and daily activities. This helps reduce unreasonably long periods of work disability.
8. Cost-effectiveness. By reducing readmissions and recurrent events, cardiovascular rehabilitation is considered a cost-effective intervention.

Despite strong evidence, cardiovascular rehabilitation remains underutilized throughout Europe. Only a fraction of eligible patients are referred to a program, and an even smaller proportion complete it. Barriers stem from the healthcare system (insufficient number of centers, lack of referral by the attending physician), the patient (distance, lack of motivation, comorbidities), and the misconception that rehabilitation is optional. Alternatives such as telerehabilitation and hybrid programs, recognized in current guidelines, can increase access to rehabilitation.

Summary: Cardiovascular rehabilitation is a complex therapeutic intervention with a Class I recommendation that reduces cardiovascular mortality, readmissions, and recurrent events, and improves quality of life. Its role extends beyond physical training: it is the starting point for secondary prevention, a framework for optimizing treatment and patient education, and a mechanism for the early detection of complications. Every eligible patient should be actively referred to a rehabilitation program.

- **Stages of Cardiovascular Rehabilitation**

The classic, generally accepted structure of a cardiovascular rehabilitation program comprises three successive phases, whose objectives and level of supervision differ significantly—an aspect detailed from the perspective of complex cases throughout this manual.

Table 23. Phases of Cardiovascular Recovery

Phase	Time / Approximate Duration	Main objective
Phase I	Hospitalization period (days – 2 weeks)	Early mobilization, prevention of complications related to immobilization, preparation for discharge
Phase II	Outpatient, supervised, 6–12 weeks	Structured exercise program, intensified education, treatment adjustment
Phase III	Indefinite, in the community or at home	Long-term maintenance of benefits achieved, periodic monitoring

- **Who is cardiovascular rehabilitation for?**

The classic, well-established indications for cardiovascular rehabilitation include:

- patients who have had a myocardial infarction, with or without coronary revascularization;
- patients who have undergone percutaneous coronary intervention or aortocoronary bypass surgery;
- patients with stable coronary artery disease, whether symptomatic or not;
- patients with stable, chronic heart failure;
- patients who have undergone valve surgery or valve intervention;
- patients with symptomatic peripheral arterial disease.

As will be discussed in detail in this chapter, this "classic" list has expanded significantly over the past decade, increasingly including patients with arrhythmias and implantable cardiac devices, elderly and frail patients, patients with ventricular assist devices or heart transplants, and adult patients with congenital heart disease—populations that go beyond the "typical" profile considered when rehabilitation programs were first designed.

- **The Proven Benefits of Cardiovascular Rehabilitation**

Cardiovascular rehabilitation is among the best-documented interventions in cardiology, with its benefits supported by decades of clinical research, summarized in numerous systematic reviews and meta-analyses.

Table22 . Proven benefits of cardiovascular rehabilitation

Area of Benefit	Results
Mortality	Reduction in cardiovascular mortality and, in some analyses, all-cause mortality
Rehospitalization	Reduction in the rate of rehospitalization for cardiovascular causes
Functional capacity	Increased exercise capacity (peak VO2, 6-minute walk test)
Quality of life	Improvement in patient-reported quality of life scores
Mental health	Reduction in symptoms of anxiety and depression
Risk factors	Improvement in lipid profile, blood pressure and blood glucose control, and increased smoking cessation rates
Cost-effectiveness	Favorable cost-benefit ratio, through reduced readmissions and long-term complications

Practical note: *The benefits of cardiovascular rehabilitation are not limited to improved exercise capacity but include demonstrated effects on mortality and healthcare costs—key arguments when advocating to decision-makers for the inclusion of these programs in standard practice.*

- **Why a Distinct Approach Is Needed for Complex Cases**

Traditional cardiovascular rehabilitation programs were initially developed for the "typical" patient with uncomplicated post-myocardial infarction and preserved or mildly reduced left ventricular function. Current clinical practice shows, however, that an increasing proportion of patients referred for rehabilitation present with complex clinical presentations: advanced heart failure, arrhythmias requiring implantable devices, multimorbidity, frailty, or status post-highly complex cardiac interventions (valvular surgery, TAVI, ventricular assist devices, heart transplantation).
The mechanical application of standard protocols to these patients may be ineffective or even dangerous. In recent years, the guidelines of the European Association for Preventive Cardiology (EAPC) and the European Society of Cardiology (ESC) have developed specific recommendations for these populations, recognizing the need for an individualized approach that goes beyond the general rehabilitation algorithm.

- **Defining the Concept of the "Complex Patient" in Cardiovascular Rehabilitation**

In cardiovascular rehabilitation, a complex patient is one to whom the standard program cannot be applied as is. Assessment, exercise prescription, or monitoring must be adapted due to the severity of the disease, comorbidities, implanted devices, or individual characteristics.
The main categories are:

1. Based on the severity and type of heart disease
   - heart failure: HFrEF, HFpEF, and especially advanced forms (Class D, EF below 30%);
   - severe post-infarction left ventricular dysfunction;
   - cardiomyopathies: dilated, hypertrophic, restrictive;
   - pulmonary hypertension;
   - arrhythmias: atrial fibrillation, ventricular arrhythmias;
   - congenital heart disease in adults.
2. Following surgery or device implantation
   - patients after cardiac surgery: coronary artery bypass grafting, valve surgery;
   - patients following percutaneous valve procedures (TAVI, mitral TEER);
   - patients with implantable devices: pacemaker, CRT, ICD, CRT-D;
   - Patients with a left ventricular assist device (LVAD);
   - patients after heart transplantation.
3. Following the progression of atherosclerotic disease
   - patients with multivessel disease: coronary artery disease associated with peripheral artery disease or cerebrovascular disease;
   - patients with symptomatic peripheral arterial disease;
   - post-stroke patients with neurological sequelae.
4. Based on comorbidities
   - diabetes mellitus, especially with complications;
   - chronic kidney disease and cardiorenal syndrome;
   - COPD and other chronic lung diseases;
   - anemia and iron deficiency;
   - severe obesity and sarcopenic obesity;
   - cardiac oncology: patients with cardiotoxicity induced by cancer treatment.
5. By age and functional status
   - elderly patients, especially those over 75–80 years of age;
   - frail patients with sarcopenia and a risk of falls;
   - patients on multiple medications.
6. By psychosocial and cognitive factors
   - patients with depression or significant anxiety;

- patients with cognitive impairment;
- patients with limited social support, isolation, or socioeconomic difficulties.

7. Underrepresented populations in studies
   - women, who are underrepresented in both clinical trials and rehabilitation programs;
   - patients with physical disabilities that limit traditional forms of exercise.

Summary: In practice, complexity most often arises from the combination of multiple categories. A typical example is the frail elderly patient with heart failure, an ICD, diabetes, and chronic kidney disease. For these patients, treatment recommendations must simultaneously adhere to the most restrictive precautions imposed by each condition

- **The Role of EAPC** *(European Association of Preventive Cardiology)* **and ESC** *(European Society of Cardiology)* **Guidelines in Standardizing Practice**

The European Society of Cardiology (ESC) periodically publishes clinical practice guidelines for major cardiovascular conditions: cardiovascular prevention, acute and chronic coronary syndromes, heart failure, valvular heart disease, peripheral arterial disease, and, more recently, cardiac rehabilitation. These guidelines are based on a systematic review of scientific evidence.

The EAPC (*European Association of Preventive Cardiology*), an association within the ESC dedicated to cardiovascular prevention and rehabilitation, has published a series of position papers and practical recommendations over the past decade focused on cardiovascular rehabilitation in special populations:

- patients with heart failure;
- patients with arrhythmias and implantable devices;
- patients with peripheral arterial disease;
- older and frail patients;
- women, who are underrepresented in both clinical trials and rehabilitation programs;
- patients with ventricular assist devices.

A key reference document is the 2021 EAPC position statement on secondary prevention through comprehensive cardiovascular rehabilitation, which defines the essential components of a rehabilitation program and the minimum standards for each patient category.

The two types of documents have complementary roles:

- the ESC guidelines establish *what* should be done—that is, the indications—along with recommendation classes and levels of evidence;
- EAPC position statements detail *how* to implement them in practice: program structure, assessment parameters, exercise prescription, and safety criteria.

EAPC documents provide practical guidance, especially for situations where conventional evidence—obtained from studies of relatively homogeneous populations (younger patients, predominantly men, with few comorbidities)—does not apply directly (recommendations are often based on expert consensus and observational studies, so the level of evidence is lower—this aspect must be understood and taken into account in clinical practice).

What these documents actually standardize

- a common language: phases of recovery, risk categories, terminology for prescribing exercise (the FITT-VP principle);
- mandatory minimum assessment prior to program enrollment: clinical evaluation, exercise testing, risk stratification;
- indications and contraindications for each patient category;
- training prescription parameters: intensity, duration, frequency, progression, tailored to the specific condition;
- safety requirements: level of supervision, monitoring during the session, emergency equipment;
- non-exercise components: risk factor management, education, and psychosocial support;
- quality indicators, which allow for the evaluation and comparison of programs across centers.

Standardization offers several practical advantages in daily practice:

- it ensures that all patients, regardless of the center where they are treated, receive care based on the same principles;
- it increases the reliability of programs through clear selection and monitoring criteria;
- it facilitates communication among members of the multidisciplinary team and between different centers;
- it provides a framework for professional training, including for students completing internships in the rehabilitation unit;
- enables the evaluation of outcomes and continuous quality improvement.

Guidelines and position statements provide guidelines, not rigid formulas. Their application requires adaptation to the individual patient, local resources, and the context of the national health care system. Furthermore, because the evidence evolves rapidly, the recommendations are updated periodically, and practitioners must follow the most recent versions.

Summary: ESC guidelines establish the indications for cardiovascular rehabilitation based on the strongest available evidence. The EAPC position papers translate these indications into practical guidelines, particularly for special populations that are underrepresented in clinical trials. Together, they form the standardization framework that ensures the safety, quality, and consistency of rehabilitation programs, while remaining guidelines that must be adapted to each patient.

- **Learning Outcomes at the End of the Chapter**
    - recognizing the pathophysiological characteristics of the main categories of complex patients in cardiovascular rehabilitation;
    - adapting the initial assessment and exercise testing to these populations;
    - prescribing individualized physical exercise, while observing the precautions specific to each patient category;
    - identifying signs of instability that require the interruption or modification of the rehabilitation program;
    - integrating EAPC/ESC recommendations into a coherent rehabilitation plan applicable in interdisciplinary practice.

2. GENERAL PRINCIPLES OF REHABILITATION FOR COMPLEX PATIENTS

- **Multidimensional Assessment of the Complex Patient**

Unlike patients with uncomplicated cardiovascular disease, the initial assessment of the complex patient must extend beyond the standard cardiological examination to include an overall functional assessment (the ability to perform basic and instrumental activities of daily living), nutritional assessment, cognitive assessment when relevant, as well as an assessment of frailty using validated tools (e.g., the Fried phenotype or clinical frailty scales).

- **The Expanded Multidisciplinary Team**

In complex cases, the standard rehabilitation team (cardiologist, physical therapist, nurse, dietitian, psychologist) often needs to be expanded to include additional specialists: a geriatrician for frail elderly patients; a nephrologist for patients with advanced chronic kidney disease; a diabetologist, for patients with difficult-to-control diabetes; and, when appropriate, the specialist who performed the highly complex procedure (cardiac surgeon, electrophysiologist, transplant team).

- **Tailoring Therapeutic Goals**

For complex patients, the goal of the rehabilitation program is not always to maximize aerobic capacity; rather, depending on the context, it may be to maintain functional autonomy, prevent further decline, improve quality of life, or reduce the number of readmissions. This reorientation of goals must be explicitly discussed with the patient and, when relevant, with the patient's family.

- **Risk Management in Complex Cases—Adapted Stratification**

The classic stratification of exercise risk (low, moderate, high), presented in the introductory chapters on cardiovascular rehabilitation, remains valid as a principle, but in complex patients, it must be supplemented with factors specific to the underlying disease—for example, NYHA class and ejection fraction in patients with heart failure, device type and programming in patients with arrhythmias, or degree of frailty in elderly patients—as detailed in the following chapters.

Practical Note: *A cross-cutting principle applicable to all categories of complex patients discussed in this chapter: in cases of uncertainty regarding the safety of exercise, the decision to initiate or continue the program must be made by a multidisciplinary team, not unilaterally by the physical therapist.*

- **Useful Functional Assessment Tools for Complex Patients**

In addition to conventional or cardiopulmonary exercise testing, a series of simple, quick-to-administer tools provide valuable supplementary information for complex patients, complementing the clinical picture obtained through standard cardiological evaluation.

Table23 . Useful functional assessment tools for complex patients

Tool	What it assesses	Usefulness in complex patients
6-minute walk test	Distance covered in 6 minutes, at the patient's own pace	Submaximal functional capacity; easy to administer in the elderly or in patients with heart failure
Walking speed over 4 meters	Usual walking speed	Component of frailty assessment, predictor of disability
Short Physical Performance Battery (SPPB)	Balance, walking speed, lower-limb strength	Comprehensive assessment of functional ability in older adults
Grip strength (dynamometry)	Overall muscle strength	Simple marker of sarcopenia and frailty
Clinical Frailty Scale	Overall frailty level (1–9)	Rapid stratification of frailty, useful in treatment decisions

- **Common barriers to participation in the rehabilitation program**

Complex cases frequently face additional barriers to access and adherence to the rehabilitation program compared to the "typical" patient: transportation difficulties related to disability or dependence on another person, an exaggerated fear of complications during exertion, the presence of depressive symptoms that reduce motivation, as well as, in certain cases, the healthcare team's lack of confidence in the safety of exercise for these patients, which may lead to them not being referred to rehabilitation programs.

Practical Note: *Tailoring the rehabilitation program to the complex patient begins with a structured, multidimensional assessment; relies on an expanded multidisciplinary team and simple yet validated functional tools; and requires awareness of specific barriers to access, which—in the absence of deliberate attention—can lead to the unjustified exclusion of these patients from rehabilitation programs.*

- **Quality Indicators for Rehabilitation Programs for Complex Patients**

Systematic monitoring of the quality of a rehabilitation program dedicated to complex cases can utilize a series of simple indicators, tracked periodically at the center level, which are useful both for the continuous improvement of the service and for providing a well-reasoned justification for the resources required for this type of activity.

Table 24 . Quality indicators for the rehabilitation program for complex patients

Indicator	**Relevance**
Enrollment rate of eligible complex patients	Measures the degree of actual access to the program, beyond theoretical eligibility
Program completion rate	Reflects both patient adherence and the program's suitability to the patient's needs
Adverse event rate during sessions	Direct indicator of program safety
Changes in functional capacity (6-minute walk test)	Measures the clinical effectiveness of the intervention
Rehospitalization rate at 30 and 90 days	Short- to medium-term clinical impact indicator
Patient-reported satisfaction	Reflects the perceived quality of the recovery experience

3. EXERCISE TESTING IN PATIENTS WITH COMPLEX CARDIOVASCULAR DISEASES

Exercise testing is the central objective tool for assessing functional capacity, risk stratification, and individualized exercise prescription in cardiovascular patients. Its role is all the more important in complex patients, in whom a subjective assessment of exercise tolerance, based exclusively on medical history, is often unreliable.

In complex patients, several factors render clinical assessment insufficient:

- exercise limitation due to non-cardiac causes: claudication, post-stroke sequelae, COPD, osteoarticular disease, or frailty can halt exercise before any myocardial ischemia becomes evident;
- medications that alter the response to exercise: beta-blockers, ivabradine, or amiodarone limit the increase in heart rate, and theoretical formulas for target heart rate become unreliable;
- implantable devices (pacemaker, CRT, ICD, LVAD), which alter the chronotropic response and impose specific safety limits;

- silent ischemia, common in diabetic and elderly patients;
- the patient's tendency to underestimate or overestimate their capacity, either due to anxiety or, conversely, denial of the disease.

For these reasons, in complex patients, exercise testing is not an optional step in the evaluation but a fundamental component of the decision to include them in the program and to determine the intensity of the intervention.

There are two main types of testing, used depending on available resources and the complexity of the case:

- standard exercise testing (electrocardiographic, ET), which primarily monitors electrical and hemodynamic changes during exercise;
- cardiopulmonary exercise testing (CPET), which adds direct, breath-by-breath measurement of gas exchange. It provides additional parameters, such as peak oxygen consumption (peak VO_2), ventilatory thresholds (VT1, VT2), and the VE/VCO_2 slope.

Table25 . Standard exercise testing versus cardiopulmonary exercise testing

Criterion	Standard exercise test (ET)	Cardiopulmonary exercise test (CPET)
Key Parameters	ECG, HR, BP, symptoms, estimated exercise capacity (MET)	All ET parameters, plus peak VO_2, VT1, VT2, VE/VCO_2 slope, RER, oxygen pulse
Exercise capacity	Indirectly estimated from the workload achieved (MET); may be overestimated in complex patients	Measured directly (peak VO_2, in ml/kg/min)
Objectivity of maximal exertion	Assessed indirectly (heart rate reached, Borg scale), unreliable under beta-blockers	Assessed objectively by peak RER ($\geq$ 1.10)
Cause of exercise limitation	Difficult to determine	Distinguish between cardiac, pulmonary, peripheral, or deconditioning-related limitations
Prescription of intensity	Target HR, % of peak HR, % of resting HR, MET	Ideal: HR at VT1 and VT2, %peak VO_2; independent of chronotropic medication
Prognostic value	Moderate	High (peak VO_2, VE/VCO_2 slope), especially in heart failure
Availability and cost	Widely available, low cost	Limited availability, higher cost, requires expertise
Situations in which it is preferred	Stable coronary patients without complex limitations; screening for ischemia	Heart failure, implantable devices, transplantation, dyspnea of unknown cause, multivessel disease, evaluation for transplantation or LVAD

- **Choosing the ergometer and protocol for complex patients**

Testing is most commonly performed on a cycle ergometer or treadmill, using protocols with progressively increasing workload. In complex patients, the choice of ergometer and protocol must be based on each patient's specific limitations, not merely on the laboratory's standard practice.

Table26 . Selection of the ergometer based on the patient's profile

Exercise Bike	Advantages	Situations in which it is preferred
Bicycle ergometer	Workload is precisely quantified (W); reduced risk of falling; blood pressure measurement and ECG recording are easier	Elderly, frail patients with balance disorders, post-stroke patients, obese patients, patients with pulmonary arterial hypertension (PAH), and those with early claudication; CPET
Treadmill	Familiar activity (walking); VO_2 values are typically about 10–15% higher	Patient with good mobility; assessment of claudication and walking distance in BAP
Semi-reclined cycle ergometer	Maximum stability; suitable for stress echocardiography	Patients with motor impairment, high risk of falling, or advanced frailty
Upper-limb ergometer	Allows testing when the lower limbs cannot be used	Amputation, severe BAP, severe osteoarticular pathology of the lower limbs (not within the first 6–8 weeks after sternotomy)

Regarding the protocol, the following is preferred for complex patients:

- individualized ramp protocols, with a continuous and slow increase in workload, calculated so that the duration of the exercise is approximately 8–12 minutes. On a cycle ergometer, the increase is usually 5–10 W/min for patients with reduced functional capacity, compared to 15–25 W/min for healthy subjects;
- on a treadmill, modified protocols with smaller increments (modified Bruce, Naughton, Balke) are used instead of the standard Bruce protocol, whose large increments may cause patients with reduced functional capacity to stop prematurely;
- an initial unloaded phase (free pedaling, 2–3 minutes), which allows the patient to adapt and stabilizes the parameters.

Practical note: *For complex patients, the choice of protocol should favor smaller increments in intensity and a longer total test duration, rather than standard protocols, which were originally designed for the general population and are often inappropriate for patients with reduced functional capacity from the outset.*

- **Technique for Conducting Exercise Testing**

During the test, the electrocardiogram, blood pressure (measured at regular intervals, usually every 2–3 minutes), and—in the case of cardiopulmonary testing—ventilatory parameters and gas exchange are continuously monitored via a mask or mouthpiece. In patients with associated lung disease, peripheral oxygen saturation (SpO_2) is also monitored. The test is conducted in the following steps:

- patient preparation: explaining the procedure, checking for contraindications, obtaining informed consent, verifying medications taken on the day of the test and the last meal (ideally 2–3 hours prior), and ensuring appropriate clothing and footwear;
- recording resting parameters: heart rate, blood pressure, resting electrocardiogram, SpO_2, and, for CPET, resting ventilatory parameters;
- the exercise phase itself, with a progressive increase in intensity, according to the chosen protocol, until reaching an endpoint: symptom-limited or, less commonly, a target heart rate. Throughout the exercise, the Borg score and symptoms are recorded periodically;
- the recovery phase, with continuous monitoring for at least 5–6 minutes after the exercise is stopped, or until the parameters return to resting values. During this interval, some of the complications of the test may occur: arrhythmias, hypotension, ischemia.

- **Specific considerations for complex patients**
  - medication: in the context of cardiovascular rehabilitation, the test is usually performed while the patient is on their usual chronic medication, including beta-blockers, so that the thresholds obtained correspond to the actual conditions under which the patient will exercise. This differs from testing for diagnostic purposes, during which beta-blockers may be temporarily discontinued, as directed by the physician;
  - Devices: The type of device and its settings (pacing rate, rate adaptation function, ICD detection zones) are checked before the test;
  - Safety: The test is conducted in the presence of a physician, with a defibrillator and emergency kit immediately available, and staff must be trained in advanced life support;
  - Diabetic patients on insulin or sulfonylureas: Blood glucose levels should be checked before the test due to the risk of exercise-induced hypoglycemia.
- **Indications for exercise testing in cardiovascular rehabilitation**
  - to establish baseline functional capacity prior to enrollment in a rehabilitation program;
  - Risk stratification for supervised exercise by identifying ischemia, arrhythmias, or abnormal blood pressure response to exercise;
  - individualized prescription of exercise intensity: target heart rate, ventilatory threshold, MET equivalent;
  - identifying the cause of exercise limitation (cardiac, pulmonary, peripheral, or due to deconditioning), particularly through CPET, in patients with dyspnea of unknown cause or with multiple comorbidities;
  - periodic reassessment of the patient's progress throughout the program to adjust intensity and objectively measure progress;
  - reassessment following significant therapeutic changes: initiation or adjustment of beta-blocker dosage, device implantation, or revascularization;
  - functional assessment prior to major therapeutic decisions, such as evaluation for heart transplantation or ventricular assist devices;
  - recommendations regarding the resumption of professional work and strenuous daily activities.

Table 27 . Contraindications to exercise testing

Absolute contraindications	Relative contraindications
Recent acute myocardial infarction (within the first 1–2 days)	Known, untreated left main coronary artery stenosis
Uncontrolled unstable angina	Moderate stenotic valvular heart disease
Uncontrolled arrhythmias with hemodynamic compromise	Significant electrolyte disturbances
Symptomatic severe aortic stenosis	Severe uncontrolled hypertension (at rest)
Decompensated, uncontrolled heart failure	Uncontrolled tachyarrhythmias or bradyarrhythmias
Pulmonary embolism or acute deep vein thrombosis	Severe obstructive hypertrophic cardiomyopathy
Acute aortic dissection	Physical or cognitive inability to safely perform the test
Acute myocarditis or pericarditis	High-degree atrioventricular block, unprotected

Practical note: *Relative contraindications do not automatically preclude testing, but require an individualized analysis of the benefit-risk ratio, often involving protocol adjustments (lower intensity, additional monitoring) or postponement of the test until the clinical situation stabilizes. In complex patients, the combination of multiple relative contraindications increases the overall risk and must be weighed accordingly.*

Table 28 . Criteria for discontinuing the exercise test

Category	Signs/symptoms requiring test termination
Symptoms	Chest pain suggestive of angina, marked dyspnea, dizziness, confusion, pallor, cyanosis
Electrocardiographic	Significant ST-segment depression or elevation, sustained ventricular arrhythmias, new-onset high-degree atrioventricular block
Blood Pressure	Decrease in systolic blood pressure below resting levels despite increased exercise intensity; excessive rise in blood pressure (typically above 250/115 mmHg)
Other signs	Signs of inadequate peripheral perfusion, the patient's express desire to stop the test, technical malfunction of the monitoring equipment

In complex patients, several specific criteria apply:

- significant desaturation (SpO_2 below 85–88% or a decrease of more than 4 percentage points from rest), especially in patients with COPD or pulmonary hypertension;
- approaching the ICD's detection zone: the test stops when the heart rate is at least 10–20 beats per minute below the lowest programmed detection rate;
- new neurological signs: speech disorders, motor deficits, balance disorders, visual disturbances;
- severe, limiting claudication in patients with peripheral arterial disease (PAD).

Practical note: *The patient's desire to stop the test, even in the absence of objective criteria for termination, is always a sufficient and legitimate reason for immediate discontinuation. The patient's autonomy takes precedence over the team's desire to obtain a "complete" test.*

- **Interpreting Results—Essential Elements for Recovery**

The result of the exercise test should not be interpreted merely as a "positive" or "negative" test for ischemia. The elements underlying treatment recommendations and risk stratification must be extracted from it.

Table 29 . Key parameters of stress testing for the recovery program

Parameter	Meaning	Use in recovery
Exercise capacity (MET, W, peak VO2)	The patient's overall functional level; compared to the predicted value for age and sex	Risk stratification; baseline for prescribing and assessing progress
Reason for stopping the test	Identifies what limits exercise: fatigue, dyspnea, angina, claudication, ECG or blood pressure criteria	Guides the type of training and necessary precautions
Ischemic threshold	HR (and workload) at which significant ST-segment depression or angina occurs	Defines the safety threshold: the training heart rate is set approximately 10 beats per minute below this threshold
Blood pressure response	Normal, excessive, or insufficient increase, or a decrease in blood pressure during exercise	A decrease in blood pressure during exercise indicates severe ventricular dysfunction or extensive ischemia, thus indicating high risk
Chronotropic response	The heart's ability to increase its rate during exercise; chronotropic incompetence if less than 80% of the predicted reserve heart rate is reached (less than approximately 62% while on a beta-blocker)	Explains reduced exercise capacity; guides intensity adjustment using the Borg scale instead of heart rate
Heart rate recovery	Decrease in heart rate during the first minute of recovery; ≤ 12 beats/min is considered abnormal	A marker of autonomic dysfunction and poor prognosis; improves with training
Exercise-induced arrhythmias	Frequent premature beats, ventricular arrhythmias, exercise-induced atrial fibrillation	May require a lower intensity and ECG monitoring during sessions
VT1 and VT2 (on CPET)	Ventilatory thresholds defining intensity zones	The most accurate guidelines for prescribing intensity, independent of medication
VE/VCO□ slope (on TECP)	Ventilation efficiency; values above 34–36 indicate inefficient ventilation	A strong prognostic marker in heart failure; also valid for submaximal tests

For the obtained values to be reliable, it must be assessed whether the effort was maximal. The criteria used are:

- Peak RER ≥ 1.10, the most objective criterion, available only with TECP;
- Borg score ≥ 17 on a 6–20 scale;
- heart rate ≥ 85% of theoretical maximum heart rate, an unreliable criterion in patients on beta-blockers, with implants, or post-transplant;
- oxygen consumption plateau, rarely reached in complex patients.

A test terminated prematurely due to non-cardiac causes (claudication, muscle fatigue, joint pain) does not rule out ischemia at a higher intensity. In these situations, the evaluation can be supplemented with pharmacological imaging stress testing.

- **Specific Features of Exercise Testing by Category of Complex Patient**

Table30 . Adapting exercise testing to the main categories of complex patients

Category	Specifics of Testing
Heart failure	CPET is preferred; ramp protocol with slow increase (5–10 W/min); key parameters: peak VO_2, VE/VCO_2 slope, VT1, RER; the test should only be performed on stable, euvolemic patients receiving optimized treatment
Devices (pacemaker, CRT, ICD)	The device's programming and the ICD's detection zones are known in advance; the test is stopped 10–20 beats/min below the detection zone; for CRTs, verify that biventricular pacing is maintained at high frequencies; for pacemakers with rate adaptation, the chronotropic response depends on the programming
LVAD	Pulse and systolic blood pressure cannot be measured conventionally (continuous flow); mean blood pressure is measured by Doppler; heart rate does not accurately reflect cardiac output; CPET is preferred; intensity is assessed using VO2, VT1, and the Borg scale
Heart Transplant	The denervated heart has a delayed and attenuated chronotropic response, and HR continues to rise even in the first minutes of recovery; HR is not a reliable marker; the Borg scale and, ideally, VT1 from CPET are used; prolonged warm-up and recovery phases
Peripheral arterial disease	Record the time or distance to the onset of claudication and the maximum distance; claudication may mask myocardial ischemia; a cycle ergometer or arm ergometer may be alternatives; post-exercise IGB, if indicated
Post-stroke	Bicycle ergometer, possibly in a semi-reclining position, for safety; pay attention to balance and motor deficits; adapt communication to aphasic patients; monitor for new neurological signs
Post-cardiac surgery	The test is usually performed after wound healing and clinical stabilization; avoid the arm ergometer during the first 6–8 weeks after sternotomy; watch for anemia and postoperative atrial fibrillation
Elderly and frail	Start with a very low initial workload (e.g., 10 W) and increments of 5–10 W/min; increased risk of falling on a treadmill; when formal testing is not possible, use the 6-minute walk test or SPPB
COPD and lung disease	Continuous SpO_2 monitoring; stop at significant desaturation; PECV distinguishes ventilatory limitation from cardiac limitation
Atrial fibrillation	Irregular heart rate with wide variations; heart rate control must be verified before the test; intensity is primarily gauged using the Borg scale
Diabetes	Risk of silent ischemia; therefore, pay attention to ECG changes even in the absence of angina; check blood glucose levels before the test in patients on insulin or sulfonylureas
Severe obesity	Check the ergometer's weight limit; a cycle ergometer is often better tolerated; VO_2 relative to body weight underestimates actual aerobic capacity

- **Objectives of exercise testing for inclusion in the rehabilitation program**

At the time of the initial evaluation, exercise testing primarily aims to:

- confirming that it is safe to begin an exercise program;
- determining the patient's risk category

- obtaining the necessary benchmarks for individualized intensity prescription: either a target heart rate or, ideally, a ventilatory threshold or a percentage of peak oxygen consumption in patients who have undergone cardiopulmonary testing;
- determining the safety threshold: the heart rate at which the first objective sign of risk (ischemia, arrhythmia, abnormal blood pressure response) occurred, which must not be exceeded during training;
- recording baseline values, against which the results of subsequent reevaluations will be compared.

- **Objectives of Exercise Testing for Monitoring the Recovery Program**

Throughout the program, periodic retesting is typically performed at the end of Phase II and, subsequently, annually or at a frequency adapted to clinical progress. It allows for:

- objectively assess functional progress;
- adjusting exercise intensity as exercise capacity changes;
- early identification of a decline in functional capacity, which may signal a worsening of the underlying disease, even before other obvious clinical signs appear.

Retesting is also necessary outside of this schedule following any significant change in treatment or clinical status: a change in beta-blocker dosage, device implantation, a new cardiovascular event, or the onset of new symptoms.

Alternatives When Formal Exercise Testing Is Not Possible

In some complex patients, formal exercise testing cannot be performed due to frailty, motor or cognitive impairments, or lack of equipment. In these situations, the following may be used:

- submaximal field tests: the 6-minute walk test, the shuttle walk test (ISWT), the walking speed test, and the SPPB;
- pharmacological imaging stress testing (dobutamine stress echocardiography, perfusion scintigraphy) to assess ischemia in patients who are unable to exercise;
- prescription based on subjective perception of exertion: Borg scale 11–13 (“light” to “moderate” exertion), starting at a low intensity and increasing cautiously under close clinical monitoring.

These alternatives allow the patient to be included in the program but do not completely replace formal testing. Exercise testing should be reconsidered as soon as the patient’s condition permits.

Summary: *Exercise testing, whether standard or cardiopulmonary, is the cornerstone of objective assessment in cardiovascular rehabilitation. It forms the basis for both the decision to safely include the patient in an exercise program and the individualized prescription of its intensity, and its periodic repetition allows for objective monitoring of progress, beyond the subjective impressions of the patient or therapist. For complex patients, testing must be adapted to each patient’s limitations (ergometer, protocol, termination criteria), and knowledge of contraindications and termination criteria is not a theoretical exercise, but an essential condition for the safe conduct of the entire rehabilitation program.*

4. THE COMPLEX CARDIOVASCULAR PATIENT—SPECIFIC ASPECTS OF REHABILITATION

3.1. Recovery in Patients with Heart Failure

- **Pathophysiological Characteristics Relevant to Recovery**

In addition to myocardial dysfunction itself, patients with heart failure exhibit significant peripheral changes—skeletal muscle dysfunction, impaired muscle oxidative capacity, endothelial dysfunction, and, frequently, sarcopenia—which contribute to exercise-related symptoms at least as much as central cardiac dysfunction. This observation underlies the rationale that physical training, though seemingly counterintuitive in a patient with a "weak" heart, is in fact a core therapeutic intervention, not merely an adjunctive measure.

- **Recovery in Patients with HFrEF (Heart Failure with Reduced Ejection Fraction)**

In patients with heart failure with reduced ejection fraction who are clinically stable, regular physical training, particularly aerobic exercise, is supported by strong evidence regarding improvements in functional capacity and quality of life, as well as a reduction in the rate of hospitalization for heart failure, without increasing the risk of adverse events when properly prescribed and supervised. The ESC guidelines recommend the inclusion of physical training in the management of these patients, with a Class I recommendation.

- **Recovery in Patients with HFpEF (Heart Failure with Preserved Ejection Fraction)**

In patients with heart failure with preserved ejection fraction—who are often elderly and have multiple comorbidities (obesity, hypertension, atrial fibrillation, diabetes)—aerobic exercise also improves functional capacity and quality of life, although the pathophysiological mechanisms differ from those in HFrEF. The exercise program must often be adapted to the limitations imposed by associated comorbidities, rather than to the severity of cardiac dysfunction alone.

- **Cardiopulmonary Exercise Testing in Patients with Heart Failure**

Cardiopulmonary exercise testing, with direct measurement of oxygen consumption, is the test of choice for prescribing exercise in patients with heart failure, as it is superior to standard exercise testing in determining the ventilatory threshold and the optimal training intensity. Parameters such as maximum oxygen consumption (peak VO_2) and the VE/VCO_2 slope also have independent prognostic value and are used for periodic assessment of the patient's progress.

- **Exercise Prescription for Patients with Heart Failure**

Moderate-intensity aerobic training remains the standard form of exercise for this patient population, with an initial short duration (10–15 minutes) that is gradually increased based on tolerance. High-intensity interval training may be considered for stable patients with low-to-moderate risk, under close supervision, as data suggest an additional benefit on aerobic capacity compared to continuous training, although this is not true for all patients. Light-to-moderate-intensity resistance training is recommended as a complementary measure to combat associated sarcopenia.

- **Signs of instability and criteria for discontinuing the program**
  - rapid weight gain (more than 2 kg in 1–3 days), suggestive of fluid and salt retention;
  - worsening of exertional dyspnea or the onset of dyspnea at rest/orthopnea;
  - newly developed or worsening peripheral edema;
  - symptomatic hypotension or new-onset arrhythmias during exertion;
  - marked fatigue, disproportionate to the level of exertion.

Practical note: *In patients with heart failure, an exercise session should be postponed—not merely reduced in intensity—in the presence of any sign of acute decompensation. The program should be resumed only after clinical stabilization, as assessed by the attending physician.*

- **The NYHA Classification and Its Implications for Exercise Prescription**

The NYHA (New York Heart Association) functional classification remains a useful practical guideline for the initial orientation of exercise prescription in patients with heart failure, although it should be supplemented, whenever possible, with objective exercise testing.

Table 31 . NYHA Classification and Implications for Exercise Prescription

NYHA Class	Description	Rehabilitation Guidelines
I	No restriction on usual physical activity	Standard aerobic program; interval training may be considered for selected patients
II	Mild restriction; symptoms with normal exertion	Moderate-intensity aerobic training, careful progression
III	Marked limitation, symptoms with minimal exertion	Low-intensity training, short, frequent sessions with breaks
IV	Symptoms at rest, aggravated by any activity	Strictly supervised exercise, often limited to passive or assisted active mobilization in a hospital setting

- **Contraindications for starting an exercise program**
    - decompensated heart failure with active signs of congestion;
    - sustained ventricular arrhythmias, not controlled by medication;
    - severe, symptomatic, untreated aortic stenosis;
    - acute myocarditis or active pericarditis;
    - mobile intracardiac thrombus with increased risk of embolism.

These contraindications are, for the most part, temporary: once the acute condition has been treated and the patient has stabilized, reassessment for inclusion in a rehabilitation program should be resumed, as permanent, unjustified exclusion deprives the patient of proven benefits.

Practical Note: *Rehabilitation for patients with heart failure, regardless of the type (HFrEF or HFpEF), is based on individualized aerobic training—ideally guided by cardiopulmonary exercise testing and oriented by NYHA class— supplemented with resistance training, careful monitoring for signs of decompensation, and recognition that contraindications are predominantly temporary in nature.*

Conclusion*: Patients with heart failure likely represent the best-documented category of "complex cases" in the literature on cardiovascular rehabilitation, and the refusal to include these patients in an exercise program—out of an excess of caution—often deprives them of an intervention with proven benefits for quality of life and readmission rates*

3.2. Post-Cardiac Surgery Rehabilitation

- **Recovery after coronary artery bypass grafting (CABG)**

Post-CABG recovery generally follows the classic three-phase structure, with some specific features related to the surgical procedure: early mobilization, typically within the first 24–48 hours postoperatively; respiratory exercises to prevent pulmonary complications; and protection of the sternum during the consolidation period (usually 6–8 weeks), during which pulling or pushing movements with the arms raised above the head and heavy lifting are avoided.

- **Recovery After Valvular Surgery**

For patients undergoing valve replacement or repair surgery, the general principles of early mobilization and sternal protection are similar to those for CABG. In addition, the type of the valve prosthesis (mechanical versus biological) and the need for oral anticoagulation must be taken into account, as these factors influence both exercise recommendations (avoiding activities with a high risk of injury) and long-term monitoring.

- **Post-TAVI (Transcatheter Aortic Valve Implantation) Recovery**

The population treated with TAVI is typically elderly and often frail, which is why the recovery program must be tailored to this reality from the outset. The advantage of the percutaneous approach—the absence of sternotomy—generally allows for faster mobilization than after conventional surgery; however, assessing frailty and comorbidities remains essential for establishing a realistic and safe program.

- **Specifics of early mobilization and sternal protection**
  - Avoid lifting weights over 4–5 kg during the first 6–8 weeks after sternotomy;
  - Avoid sustained pushing or pulling movements with the arms (e.g., standing up from a seated position using only the arms);
  - encouraging breathing exercises and lower limb mobilization beginning during the hospital stay;
  - closely monitor the sternal wound for signs of dehiscence or infection.

Practical Note: *The physical therapist involved in Phase I of recovery must be explicitly informed of the type of surgical procedure and its date, as precautions related to sternotomy differ significantly from those of a percutaneous procedure such as TAVI.*

Table 32 . Postoperative complications relevant to the physical therapist

Complication	Signs to Look For	Implications for the rehabilitation program
Sternal dehiscence	Instability, crepitus, severe local pain, discharge from the wound	Immediately discontinue upper body exercises; notify the surgical team
Postoperative atrial fibrillation	Irregular pulse, palpitations, sometimes asymptomatic	Reassess exercise tolerance; correlate with anticoagulation status
Pericardial effusion	Shortness of breath, hypotension, tachycardia	Suspend the exercise program; urgent cardiological evaluation
Postoperative pneumonia/atelectasis	Fever, dyspnea, decreased oxygen saturation	Focus on breathing exercises; postpone intense aerobic training

- **Timelines for resuming activities**

A general guideline, useful for counseling patients after sternotomy, is presented in the table below; however, exact timelines must always be confirmed with the surgical team, depending on the specifics of each case.

Table 33 . Timelines for Resuming Activities After Sternotomy

Activity	Approximate timeline for resuming
Light walking, light household activities	Starting during hospitalization, gradually
Driving	Approximately 4–6 weeks, with the attending physician's approval
Lifting weights over 4–5 kg	After sternal healing, usually 6–8 weeks
Sexual activity	Approximately 2–4 weeks, provided there are no symptoms during equivalent exertion
Return to work (sedentary)	Approximately 4–6 weeks
Return to physically demanding work	Approximately 3 months, on an individual basis

Practical note: *Regardless of the type of cardiac surgery, recovery must combine early mobilization with adherence to specific precautions related to the surgical approach (sternotomy versus percutaneous approach) and the type of implanted device, with prompt recognition of postoperative complications and clear communication regarding the timeline for resuming activities, tailored individually to each patient.*

3.3. Recovery in Patients with Arrhythmias and Implantable Cardiac Devices

- **Recovery in patients with atrial fibrillation**

Atrial fibrillation, which is frequently associated with other forms of cardiovascular disease, does not in itself contraindicate a rehabilitation program. Regular physical training may help some patients reduce arrhythmic burden and improve exercise tolerance, provided that ventricular rate and anticoagulation status are adequately controlled when indicated.

- **Rehabilitation in Patients with an Implantable Cardioverter-Defibrillator (ICD)**

Patients with an ICD can and should generally be included in cardiovascular rehabilitation programs, as regular physical exercise is not associated with an increase in the rate of appropriate or inappropriate device shocks in stable patients. It is essential that the intensity of exercise be prescribed such that the maximum heart rate reached during training remains below the device's detection threshold for ventricular arrhythmias; this information must be obtained from the electrophysiologist before initiating the program.

- **Rehabilitation in Patients with Cardiac Resynchronization Therapy (CRT)**

In patients with CRT, who often also have heart failure, the recovery program follows the principles described in Chapter 3, with additional reported benefits regarding exercise capacity attributed to both electrical resynchronization and physical training itself, as the two interventions complement each other.

- **Device-Specific Precautions**
    - Avoid wide, repetitive movements of the arm on the same side as the device implantation site during the first 4–6 weeks after implantation;
    - Be aware of the heart rate threshold at which the device intervenes (antitachycardia therapy or shock) to prevent exceeding it during exercise;
    - educating the patient on what to do if the device delivers therapy during or after exercise (stop the activity, notify the medical team).

Practical Note: *Direct communication with the electrophysiologist to obtain the device's programming parameters (arrhythmia detection rate, configured therapy type) is a mandatory step before prescribing exercise for any patient with an implantable cardiac device.*

Table 34 . Summary of types of implantable cardiac devices

Device Type	Main Indication	Specific exercise precautions
Cardiac pacemaker	Bradyarrhythmias, atrioventricular block	Assessment of the chronotropic response to exercise, especially in older devices without an activity sensor
ICD (implantable cardioverter-defibrillator)	Primary/secondary prevention of sudden arrhythmic death	Exercise intensity below the detection threshold for ventricular arrhythmias
CRT (cardiac resyn-chronization therapy)	Heart failure with left bundle branch block	Combining CRT precautions with principles of recovery from heart failure
Implantable cardiac monitor (loop recorder)	Diagnosis of rare arrhythmias and syn-cope of unknown cause	No specific exercise restrictions; used solely for monitoring

- **Patient education for device wearers**

The patient must be clearly informed about the symptoms that require immediate cessation of activity (severe palpitations, a sensation of a shock in the chest, marked dizziness), as well as on what to do next—notifying the medical team and, in the case of a perceived shock, seeking prompt medical evaluation, even if the patient's general condition subsequently appears normal.

Practical note: *The presence of an arrhythmia or an implantable cardiac device is not, in itself, a contraindication for cardiovascular rehabilitation, but requires careful coordination with the electrophysiology team, precise knowledge of the device type and its programming parameters, as well as structured patient education regarding what to do if a shock is delivered during exercise*

3.4. Rehabilitation in Patients with Peripheral Arterial Disease

- **Supervised walking training**

In patients with symptomatic peripheral arterial disease (intermittent claudication), structured walking training, conducted under supervision, is the non-pharmacological intervention with the strongest level of evidence, with effects comparable to or superior to some revascularization interventions in terms of pain-free walking distance and maximum walking distance.

- **Endurance training in patients with claudication**

The classic protocol involves walking until moderate-to-severe pain develops in the lower limbs, followed by a short rest period, then resuming walking; this cycle is repeated throughout the training session (typically 30–60 minutes), 3–5 times a week, for a minimum of 12 weeks to achieve maximum benefit.

- **Management of Associated Risk Factors**

Peripheral arterial disease is a marker of systemic atherosclerosis; for this reason, in addition to walking training, patients require rigorous control of other cardiovascular risk factors (smoking, dyslipidemia, hypertension, diabetes), as the risk of coronary and cerebrovascular events in this population is substantially increased and is often a more relevant prognostic factor than the local progression of peripheral arterial disease.

Practical note: *Claudication-type pain that occurs during exercise is not a warning sign requiring permanent cessation of exercise, but rather an integral part of the therapeutic protocol—an important point to communicate to the patient, who may initially associate the pain with danger and thus avoid the beneficial exercise.*

- **Classification of the Severity of Peripheral Arterial Disease**

The Fontaine classification, frequently used in European practice, guides therapeutic decisions and the recommendation for supervised walking training:

Table 35 . The Fontaine Classification and the Role of Exercise-Based Rehabilitation

Fontaine Stage	Clinical description	Role of exercise rehabilitation
I	Asymptomatic; disease detected only by a low ankle-brachial index	Primary prevention, aggressive management of risk factors
II	Intermittent claudication (IIa—long-distance, IIb—short-distance)	Main indication for structured walking training
III	Ischemic rest pain	Evaluation for revascularization; limited, individualized exercise
IV	Ulcers or gangrene	Priority: revascularization and wound care; severely limited exercise

- **The role of rehabilitation before and after revascularization**

In patients who are candidates for revascularization (endovascular or surgical), supervised walking training may be offered as a first-line therapy, especially in Fontaine Stage IIa, or as a complementary intervention, both before and after the revascularization procedure, as evidence supports a greater functional benefit when exercise is combined with—rather than merely used as an alternative to—revascularization.

Summary:

Practical Note: *In patients with peripheral arterial disease, structured walking training, performed up to the threshold of moderate pain, represents a first-line intervention with solid functional benefits, applicable especially in Fontaine stages I–IIb and as a complement to revascularization in more advanced stages, which must be combined with aggressive control of systemic cardiovascular risk factors.*

3.5. Recovery in the Elderly and Frail Patient

- **Assessment of Frailty**

Frailty is a clinical syndrome characterized by reduced physiological reserve and the ability to cope with stressors, associated with an increased risk of complications, disability, and mortality. Tools such as the Fried phenotype (assessing unintentional weight loss, fatigue, grip strength, walking speed, and level of physical activity) or clinical frailty scales allow for the systematic identification of these patients, who require a different approach than that of active, non-frail older adults.

- **Adapting the Exercise Program for the Frail Older Adult**

For frail older adults, the rehabilitation program should begin at a low intensity, with slow progression and realistic goals, focused more on maintaining functional autonomy than on optimizing aerobic capacity. Strength training, even at submaximal intensities, plays an essential role in combating sarcopenia, and balance training should be systematically included.

- **Preventing Sarcopenia and Falls**

Sarcopenia—the age-related loss of muscle mass and strength—is often exacerbated by repeated hospitalizations and prolonged periods of rest necessitated by acute cardiovascular events. Progressive resistance training, combined with balance exercises, reduces the risk of falls and helps maintain functional independence—a goal that is often just as important for these patients as reducing cardiovascular risk itself.

Practical Note: *In frail older adults, a "too cautious" rehabilitation program—one that avoids any form of exertion for fear of complications—can be just as harmful as an overly aggressive program: prolonged inactivity accelerates functional decline and increases the risk of dependency.*

Table 36 . Clinical Frailty Scale

Score	Description
1–3	Robust—active, energetic, with no significant functional limitations
4	Vulnerable – slight slowing, no dependence in daily activities
5–6	Mild to moderate frailty – requires assistance with complex instrumental activities
7–8	Severe frailty – dependent for most basic activities
9	Terminal illness

Patients with a score of 5–6 typically represent the target population for the adaptations described in this chapter: functional enough to benefit from a structured exercise program, but with reduced physiological reserve, which requires caution and gradual progression.

Table 37 . Suggested structure of a session adapted for the frail older adult

Component	Approximate Duration	Notes
Warm-up	5–10 minutes	Light joint mobility exercises, slow walking
Aerobic component	10–20 minutes	Light to moderate intensity, with breaks as needed
Strength exercises	10–15 minutes	Submaximal intensity, slow progression
Balance exercises	5–10 minutes	Same priority as the aerobic component
Cool-down / relaxation	5 minutes	Monitoring heart rate recovery

Practical note: *Recovery in frail older adults requires a structured assessment of frailty (e.g., using the Clinical Frailty Scale), therapeutic goals focused on functionality and autonomy, slow progression of exercise, and the systematic integration of strength and balance training into every session, alongside the traditional aerobic component.*

3.6. Rehabilitation for Patients with Diabetes Mellitus and Associated Chronic Kidney Disease

- **Specifics of Exercise Prescription for Diabetic Patients**

In patients with diabetes mellitus and associated cardiovascular disease, regular physical exercise offers dual benefits—cardiovascular and metabolic—improving insulin sensitivity and long-term glycemic control. Potential associated microvascular complications (retinopathy, peripheral neuropathy) must be considered, as they may influence the choice of exercise type (for example, avoiding high-impact exercises in patients with severe peripheral neuropathy).

- **Risk of Hypoglycemia and Its Management**

Patients on insulin or sulfonylurea therapy are at increased risk of exercise-induced hypoglycemia, especially during high-intensity or prolonged exercise sessions. It is recommended to check blood glucose levels before and, when possible, during prolonged ex e sessions, as well as to educate the patient on the early recognition and management of hypoglycemia symptoms.

- **Recovery in Patients with Chronic Kidney Disease**

Chronic kidney disease, which is frequently associated with diabetes and hypertension, increases overall cardiovascular risk and requires extra attention to the management of circulating volume and blood pressure levels during the rehabilitation program. For patients on dialysis, exercise sessions can be scheduled both on non-dialysis days and, with additional precautions, during or immediately after the dialysis session, depending on the center's protocol and individual tolerance.

Practical Note: *For diabetic patients on hypoglycemic therapy, the physical therapist must have easy access to a rapid source of glucose in the recovery room and be familiar with the early signs of hypoglycemia in order to intervene promptly*

Table 38 . Guideline blood glucose levels for safe exercise

Pre-exercise blood glucose level	Recommended action
< 90 mg/dl	Consume carbohydrates before starting exercise
90–250 mg/dl	Exercise can be safely initiated
> 250 mg/dl, with ketonuria	Postpone exercise; seek medical evaluation
> 300 mg/dl, without ketonuria	Caution, adequate hydration, close monitoring

- **Special considerations for dialysis patients**

For patients on chronic hemodialysis, the optimal time for exercise remains a subject of debate: some centers prefer days without dialysis to avoid acute volume fluctuations, while others have successfully integrated exercise directly into the dialysis session under close supervision, with reported benefits regarding adherence to the exercise program due to the already scheduled visit to the medical facility. The choice must be tailored to each individual, depending on the resources and protocol of each center.

Practical Note: *Diabetes mellitus and chronic kidney disease, which frequently coexist in cardiovascular patients, do not contraindicate physical exercise, but require specific attention to the risk of hypoglycemia—guided, whenever possible, by specific blood glucose targets—to associated microvascular complications, and to the management of circulating volume, especially in dialysis patients, for whom the timing of exercise must be determined on an individual basis.*

3.7. Recovery in Patients with Multimorbidity and Polypharmacy

- **Challenges of the recovery program for patients with multimorbidity**

The simultaneous presence of multiple chronic conditions (e.g., cardiovascular disease, chronic obstructive pulmonary disease, osteoarthritis, mild cognitive impairment) complicates the development of a unified rehabilitation program, as each associated condition may limit, in different ways, the type or intensity of exercise that can be tolerated. In these cases, prioritizing therapeutic goals in consultation with the patient becomes just as important as selecting the exercise protocol itself.

- **Management of Polypharmacy in the Context of Rehabilitation**

Multimorbid patients are frequently on treatment with numerous classes of medications, some of which can directly influence the response to exercise—for example, beta-blockers limit the increase in heart rate during exercise, which is why prescribing exercise intensity based solely on target heart rate can be misleading in these patients; it is preferable to use the Borg scale of subjective exertion as a complementary or primary guide.

Practical note*: In patients receiving beta-blocker therapy, monitoring exercise intensity exclusively through the classically calculated target heart rate may underestimate the actual effort expended; the Borg scale becomes, in these situations, a more reliable reference tool.*

Table 39 . Common medication–exercise interactions relevant to physical therapists

Drug class	Effect on exercise response	Practical Implications
Beta-blockers	Limit the increase in heart rate during exercise	Using the Borg Scale as the Primary Measure of Intensity
Diuretics	Risk of volume depletion, orthostatic hypotension	Pay attention to hydration; monitor blood pressure upon standing
Vasodilators / nitrates	Risk of hypotension, especially when combined with exertion	Avoid sudden changes in posture; monitor blood pressure
Insulin / sulfonylureas	Risk of exercise-induced hypoglycemia	Check blood glucose levels according to the guidelines
Oral anticoagulants	Increased risk of bleeding in case of trauma	Avoid exercises with a high risk of impact or falls

Practical note: *In patients with multiple comorbidities, the success of the rehabilitation program depends less on the complexity of the exercise protocol and more on the team's ability to prioritize realistic goals, to account for drug interactions relevant to exercise response—summarized above for the most common therapeutic classes—and to continuously adapt the program to the progression of each comorbid condition.*

3.8. Rehabilitation in Patients with a Ventricular Assist Device and Heart Transplant

- **Rehabilitation in patients with a left ventricular assist device (LVAD)**

Patients with an LVAD—implanted either as a destination therapy or as a bridge to transplantation—benefit from tailored rehabilitation programs aimed at improving functional capacity and quality of life, with specific precautions regarding the external power lead (driveline)—avoiding traction or trauma to this area—and monitoring device-specific parameters during exercise.

- **Post-Heart Transplant Rehabilitation**

The transplanted heart exhibits important physiological characteristics, particularly cardiac denervation, which significantly alters the heart rate response to exercise: the resting heart rate is typically higher than normal, its increase at the onset of exercise is delayed, and the return to resting values after exercise ceases is also slower. These characteristics require a longer warm-up period and exercise intensity guidelines based on the patient's subjective perception of exertion, rather than exclusively on heart rate.

Practical note: *In heart transplant patients, the absence of typical anginal pain—due to denervation—means that warning signs during exercise are often atypical (marked dyspnea, unusual fatigue); for this reason, monitoring must pay particular attention to these nonspecific manifestations.*

- **Specific Monitoring Parameters for Patients with an LVAD**
  - parameters displayed by the device (pump speed, flow rate, pulsatility index), which must be checked together with the LVAD-specialized team before and during exercise sessions;
  - mean arterial pressure, determined using appropriate methods (Doppler), since many patients with continuous-flow LVADs do not have a classic palpable pulse;
  - the condition of the external power line (driveline) insertion site, for signs of infection or excessive traction;
  - signs of right ventricular failure, a relatively common complication in this population (edema, jugular distension, hepatomegaly).

- **Additional Considerations Following Heart Transplantation**

In addition to the cardiac denervation discussed earlier, the post-transplant patient is on chronic immunosuppressive therapy, which requires increased attention to the risk of infection in group recovery settings (equipment hygiene, avoiding contact with individuals with active infections) and to the possible musculoskeletal side effects of immunosuppressive therapy (corticosteroid myopathy, osteoporosis), which are relevant to the selection of the type and intensity of resistance exercise.

Practical Note: *Both patients with a ventricular assist device and those who have undergone a heart transplant can benefit significantly from a structured rehabilitation program, provided that the entire team involved has a thorough understanding of the specific physiological characteristics (cardiac denervation, external power supply, immunosuppression) and monitors specific parameters that differ from those used in standard cardiovascular rehabilitation.*

3.9. Rehabilitation in Adult Patients with Congenital Heart Disease

- **Assessment Considerations**

The adult population with congenital heart disease is extremely heterogeneous, comprising both patients with simple defects that were fully corrected in childhood and patients with complex anatomy (e.g., Fontan circulation) and significantly reduced functional capacity. The evaluation of these

patients ideally requires collaboration with a specialist in adult congenital cardiology, as the specific risks and limitations vary drastically depending on the type of defect and previous interventions.

- **Exercise Prescription**

For most patients with corrected congenital heart disease, with the exception of specific high-risk forms, regular physical exercise is beneficial and recommended, as it helps maintain functional capacity in the long term. However, the prescription must be strictly individualized, taking into account the type of defect, any associated arrhythmias, and functional capacity as documented by exercise testing.

Table 40 . Congenital Heart Disease in Adults—Guidance by Complexity Categories

Complexity Category	Examples	Exercise Guidelines
Simple, corrected complexity	Corrected atrial/ventricular septal defect, without sequelae	Unrestricted physical activity, similar to the general population
Moderate complexity	Corrected tetralogy of Fallot, corrected aortic coarctation	Aerobic exercise recommended, with periodic evaluation of arrhythmias and ventricular function
High complexity	Fontan circulation, transposition of the great arteries with atrial switch	Strictly individualized treatment plan, specialized team, mandatory exercise testing

Practical note: *Congenital heart disease in adults should not be treated as a single category, but rather as a broad spectrum of clinical conditions, ranging from simple, corrected defects to complex anatomies such as the Fontan circulation; each category has its own recommendations, and collaboration with a specialist in congenital heart disease in adults is essential for the safety of the rehabilitation program.*

3.10. Specifics of Cardiovascular Rehabilitation in Women

- **Underrepresentation of women in rehabilitation programs**

Available data consistently show that women are underrepresented in cardiovascular rehabilitation programs; they are referred to these programs less frequently and have a lower completion rate than men, despite documented benefits that are similar or even superior in certain respects. There are multiple causes for this disparity: logistical barriers related to family responsibilities, the mistaken perception of heart disease as predominantly "male," as well as differences in the presentation of symptoms of coronary artery disease.

- **Program Adaptation**

Women enrolled in rehabilitation programs are, on average, older at the time of their cardiovascular event and are more likely to have associated comorbidities than men, which often requires an approach that overlaps with the principles discussed in the chapters on older and multimorbid patients. Flexible programs that take specific time constraints into account and offer options such as home-based rehabilitation or telerehabilitation can improve participation and completion rates in this population.

Practical Note: *Actively identifying and addressing specific barriers to participation among women—rather than simply offering the same standard program—is an essential component of reducing the current disparity in access to cardiovascular rehabilitation.*

- **Physiological Differences Relevant to Exercise Prescription**

On average, women have a lower maximum aerobic capacity than men of the same age, as well as a lower relative muscle mass; these factors must be taken into account when determining the absolute intensity of exercise (expressed in METs or watts), without, however, implying that the relative

benefit of training is reduced—on the contrary, some studies suggest that the benefits of cardiovascular recovery in women are at least as significant as those in men.

3.11. Recovery in Cardiac-Oncology Patients

- **Cardiotoxicity Associated with Cancer Treatments**

Advances in cancer therapy have led to a significant increase in survival rates among cancer patients, but some of the therapies used—anthracyclines, anti-HER2 therapies, tyrosine kinase inhibitors, and thoracic radiation therapy—are associated with a risk of cardiotoxicity, manifested as left ventricular dysfunction, heart failure, accelerated coronary artery disease, or arrhythmias. This population, at the intersection of oncology and cardiology, represents a relatively new but rapidly growing category among complex patients referred for cardiovascular rehabilitation.

- **Specifics of the Evaluation of Cardio-Oncology Patients**

The evaluation of these patients must integrate both their current cardiovascular status (ventricular function, presence of heart failure symptoms) and their oncological status—the type of treatment received, the time elapsed since the last course of chemotherapy or radiation therapy, as well as any hematologic side effects (anemia, thrombocytopenia), which can directly influence exercise safety and tolerance.

- **Exercise Prescription for Patients with Cardiovascular and Oncological Conditions**

Moderate-intensity aerobic exercise is generally well tolerated and recommended both during and after completion of cancer treatment, as there is evidence of a protective effect on cardiac function and an improvement in treatment-related fatigue—one of the most common and debilitating symptoms reported by this population. However, the intensity and type of exercise must be adjusted based on current hematological values, the risk of bleeding, and the patient's level of fatigue.

Practical Note: *In patients currently undergoing active cancer treatment, hematologic values (hemoglobin, platelet count, neutrophil count) should be checked before initiating or continuing an exercise program, in collaboration with the oncology team, as these may temporarily contraindicate certain types of exercise.*

Summary: *Cardiovascular rehabilitation in patients with both heart disease and cancer is an emerging field that requires close collaboration between the cardiology and oncology teams, with the exercise program tailored to both cardiac status and the specific characteristics and side effects of ongoing or recently completed cancer treatment.*

5. RISK STRATIFICATION AND EXERCISE SAFETY IN COMPLEX PATIENTS

- **High-risk criteria for supervised exercise**
  - decompensated or unstable heart failure in the past few weeks;
  - sustained, uncontrolled ventricular arrhythmias;
  - severe, symptomatic, untreated aortic stenosis;
  - severe pulmonary hypertension;
  - hemodynamic instability or symptomatic hypotension with minimal exertion;
  - severe frailty, with a significant risk of falling or decompensation with minimal exertion.
- **Emergency Protocols During Rehabilitation Sessions**

Every cardiovascular rehabilitation center that works with complex patients must have a written emergency protocol, known to all staff, that includes rapid access to resuscitation equipment and an automated external defibrillator, as well as a direct line of communication with the on-call medical team, for situations in which signs of instability arise during an exercise session.

Practical Note: *A rehabilitation program that includes high-risk patients cannot operate safely without staff trained in basic cardiopulmonary resuscitation and without emergency equipment immediately available at the session location.*

Table 41 . Risk stratification for supervised exercise—summary by category

Risk category	Key Characteristics	Recommended level of supervision
Low	Good functional capacity, no ischemia or arrhythmias on exercise, preserved ventricular function	Standard monitoring, intermittent monitoring
Moderate	Symptoms or electrocardiographic changes during moderate-to-high exertion, mild-to-moderate ventricular dysfunction	Continuous monitoring during the first sessions, followed by periodic reassessment
High	Ischemia/arrhythmias with minimal exertion, severe ventricular dysfunction, hemodynamic instability, severe frailty	Continuous monitoring, staff trained in emergency care, immediate access to resuscitation equipment

- **Practical recommendation for a gradual approach**

For high-risk patients, a progressive approach is recommended: start the program with short, low-intensity sessions under continuous direct supervision, followed by a gradual increase in duration and intensity, contingent upon the absence of any signs of instability during previous sessions, rather than establishing a standard protocol from the outset that is identical to that used for low-risk patients.

6. NUTRITIONAL STATUS AND SARCOPENIA IN PATIENTS WITH COMPLEX CARDIOVASCULAR DISEASE

- **Cardiac cachexia**

Cardiac cachexia, defined as significant unintentional weight loss in patients with chronic heart failure, is a marker of poor prognosis, associated with increased mortality regardless of the severity of cardiac dysfunction. Unlike obese patients, where the goal is weight loss - the nutritional goal in cachectic patients is completely reversed, focusing on maintaining adequate caloric and protein intake.

- **Sarcopenia in Cardiovascular Patients**

Sarcopenia - a reduction in muscle mass and strength is common in elderly cardiovascular patients or those with advanced heart failure, and is exacerbated by periods of hospitalization and prolonged bed rest. Diagnosis is based on measurements of muscle strength (dynamometry), muscle mass (when methods for assessing body composition are available), and physical performance (walking speed, chair stand test).

- **Combined Intervention - Nutrition and Exercise**

In patients with cachexia or sarcopenia associated with cardiovascular disease, resistance exercise combined with adequate protein intake (approximately 1.0–1.2 g protein/kg body weight/day in older adults, with individual adjustment based on renal function), is the intervention with the strongest evidence for counteracting muscle mass loss; exercise alone, without adequate nutritional support, has a limited effect in these patients.

Table42 . Combined nutrition–exercise intervention based on nutritional status

Nutritional status	Primary objective	Role of physical exercise
Obesity	Moderate caloric deficit, 5–10% weight loss	Increased aerobic component, combined with resistance training
Normal weight, without sarcopenia	Maintenance of nutritional status	Standard, balanced aerobic-resistance program
Sarcopenia, without excess weight	Increased protein intake, adequate caloric intake	Emphasis on progressive resistance training
Cardiac cachexia	Active caloric and protein support; avoid restriction	Low-intensity exercise focused on maintaining function, not on creating a caloric deficit

Practical note: *In patients with advanced heart failure, unintentional weight loss should not automatically be interpreted as a favorable sign—it may, in fact, represent the onset of cardiac cachexia and requires prompt nutritional assessment, not congratulations on "weight loss."*

Summary: *The nutritional status of patients with complex cardiovascular conditions must be actively assessed, not assumed: at the opposite end of the spectrum from obesity, cardiac cachexia and sarcopenia are common and underdiagnosed complications, the proper management of which requires reversing traditional nutritional goals and combining resistance exercise with adequate protein intake.*

7. CARDIAC TELEREHABILITATION IN COMPLEX CASES

- **Telerhabilitation Models**

Cardiac telerehabilitation, which has been extensively developed and validated in recent years, encompasses a variety of models—ranging from remote monitoring of vital signs during home exercise to real-time supervised video sessions—and has proven, in low- to moderate-risk patients, to be just as effective as traditional in-center rehabilitation in terms of improving functional capacity.

- **Indications and Limitations in Complex Patients**

In complex patients—those with advanced heart failure, implantable cardiac devices, or high risk during exercise testing—telerehabilitation should be approached with extra caution, as it is often more appropriate as a complementary element or as a continuation of Phase III, following an initial period of direct supervision at the center, rather than as the sole modality of recovery starting in Phase II.

> **Practical Note:** *The decision to recommend telerehabilitation, in place of or alongside the traditional in-center program, must take into account both the patient's risk category and their ability (or that of a caregiver) to use the necessary remote monitoring equipment.*

Table 43 . Summary of telerehabilitation models

Model	Description	Recommended population
Remote monitoring, home exercise	Wearable device/app transmits heart rate, steps, and sometimes a simplified ECG	Low-to-moderate risk, motivated patients with access to technology
Real-time supervised video sessions	Physical therapist guides the session via videoconference	Low-to-moderate risk, requiring active guidance
Hybrid model (center + home)	Alternating between sessions at the center and sessions at home	Transition from supervised Phase II to Phase III

8. CASE STUDIES

- **Case 1**

A 74-year-old female patient with chronic heart failure with reduced ejection fraction (EF 32%), permanent atrial fibrillation on anticoagulant therapy, type 2 diabetes mellitus treated with insulin, and stage 3b chronic kidney disease. The patient was recently hospitalized for cardiac decompensation; she is currently clinically stable, with a clinical frailty score suggestive of mild-to-moderate frailty. She is referred to a Phase II cardiovascular rehabilitation program.

Requirements:

1. Identify all the factors that classify this patient as a "complex case," according to the criteria discussed in the textbook.
2. Propose the composition of the multidisciplinary team needed to manage this case.
3. Develop an initial evaluation plan, including exercise testing and frailty assessment.
4. Describe the specific considerations for prescribing physical exercise, taking into account the patient's heart failure, atrial fibrillation, diabetes, and frailty.
5. List the specific warning signs that the team must actively monitor in this patient.

Practical Note: *This case study illustrates a common situation in real-world practice: the overlap of multiple categories of complexity in the same patient. The graduate student is encouraged to explicitly identify how the recommendations specific to each condition should be integrated, rather than simply juxtaposed.*

- **Case 2**

A 62-year-old patient, 3 weeks post-coronary artery bypass grafting (sternotomy), with a history of sustained ventricular tachycardia for which an implantable cardioverter-defibrillator (ICD) was implanted, programmed with a detection threshold of 180 bpm. The patient is functionally independent, shows no signs of frailty, and is eager to resume physical activity as soon as possible.

Requirements:

1. Determine the safe target heart rate range for aerobic exercise, taking into account the ICD's detection threshold.
2. List the specific precautions related to the recent sternotomy, applicable in conjunction with those related to the ICD.
3. Propose a suggested structure for the first three recovery sessions, taking both sets of precautions into account.

Practical Note: *This case illustrates another common situation: the overlap of a temporary surgical precaution (sternotomy) with a permanent, device-related precaution (the ICD's detection threshold)—the two types of restrictions have different time frames and must be managed separately.*

GUIDELINES FOR SOLVING CASE STUDIES

Case 1 (heart failure, atrial fibrillation, diabetes, frailty)

- Complexity factors: HFrEF, permanent atrial fibrillation, insulin-treated diabetes, stage 3b chronic kidney disease, mild-to-moderate frailty, recent hospitalization;
- Recommended team: cardiologist, physical therapist, diabetologist or internist with experience in diabetes, dietitian, possibly a geriatrician, given the degree of frailty;
- Initial assessment: cardiopulmonary exercise testing or, if unavailable, adapted submaximal testing, frailty assessment (e.g., Clinical Frailty Scale), review of recent glycemic control;
- Exercise prescription: initially low intensity, slow progression, prioritizing balance and strength exercises alongside the aerobic component, checking blood glucose levels before exercise;
- Warning signs to actively monitor: rapid weight gain, worsening dyspnea, signs of hypoglycemia, irregular pulse with associated symptoms.

Case 2 (post-CABG, ICD recipient)

- the target heart rate should be set with a safety margin below the detection threshold of 180 bpm (for example, limited to a maximum of 20–30 bpm below this threshold, as confirmed by the electrophysiologist);
- Sternal precautions: Avoid upper-body exercises involving sustained pulling or pushing and lifting weights over 4–5 kg for 6–8 weeks following the procedure;
- initial sessions: focus on supervised walking and breathing exercises, light lower-body exercises, avoidance of any active use of the shoulder girdle, and continuous monitoring of heart rate to remain below the established safety threshold.

9. CONCLUSIONS

Cardiovascular rehabilitation for complex patients is not simply an extension of the standard protocol. It is a distinct approach based on several essential principles:

- **Understanding the specific characteristics of each patient category.**

Heart failure, implantable devices, heart transplantation, multivascular disease, advanced age and frailty, and associated comorbidities: each of these factors alters the response to exertion, the risks of exercise, and how the program should be structured. Proper prescription always begins with an understanding of the pathophysiological mechanisms specific to each patient.

- **Objective assessment as the foundation of decision-making.**

In complex patients, clinical assessment and subjective impressions of exercise tolerance are often unreliable. Exercise testing—whether standard or cardiopulmonary—supplemented by functional tests and an evaluation of comorbidities, provides objective benchmarks for safe inclusion in the program and for determining the appropriate intensity.

- **Consistent individualization of therapeutic goals.**

Goals are not the same for all patients. For some, the primary goal is to increase exercise capacity. For others, it is to maintain functional independence, prevent readmissions, or improve quality of life. Goals are established in collaboration with the patient and reassessed throughout the program.

- **Adherence to the most restrictive precaution.**

When multiple conditions coexist, treatment must simultaneously adhere to the safety limits imposed by each condition, not an average of them. The most restrictive threshold becomes the program's limit.

- **Extensive interdisciplinary collaboration.**

A complex patient cannot be managed by a single specialist. The cardiologist, rehabilitation physician, physical therapist, nurse, dietitian, psychologist, and, as appropriate, the neurologist, vascular surgeon, or the heart failure and device team must work in a coordinated manner, with clear communication and rigorous documentation.

- **Rehabilitation as a complex intervention, not just physical training.**

Maximum benefits are achieved when exercise is combined with risk factor management, optimization of pharmacological treatment, patient and family education, psychological support, and planning for social and professional reintegration.

- **Guidelines as guidelines, not as prescriptions.**

The ESC guidelines and EAPC position statements provide a solid framework for this approach. However, in the case of complex patients, the evidence often comes from studies involving populations that are more homogeneous than those encountered in real-world practice. Their application at the patient's bedside remains, ultimately, an act of individualized clinical reasoning.

The central message of this chapter is that **clinical complexity is not, in itself, a contraindication for rehabilitation**:

- although it increases the potential risks of physical exercise, clinical complexity precludes rehabilitation only in specific, well-defined situations;
- paradoxically, complex patients are the ones who stand to gain the most from a rehabilitation program: they have the lowest functional capacity, the highest risk of readmission, and the greatest need for support in self-managing their condition;
- precisely for this reason, complexity provides an **additional reason** to offer them access to an intervention whose benefits—carefully tailored—remain substantial;
- The real risk does not stem from including these patients in the program, but rather from **their unjustified exclusion** or from a treatment plan that is not tailored to their specific needs.

Finally, it should be emphasized that this field is **constantly evolving**:

- the population of cardiovascular patients is aging, and multimorbidity is becoming the rule rather than the exception;

- therapeutic technologies are becoming increasingly sophisticated: implantable devices, percutaneous procedures, ventricular assist devices, and new therapies for heart failure and obesity;
- telerehabilitation and hybrid programs are expanding access to recovery for patients who cannot participate in traditional programs;

Appendix 1. Guideline for the Initial Assessment of a Complex Patient

The form below is intended as a guideline and educational tool, useful for structuring the initial assessment of a complex patient prior to enrollment in a cardiovascular rehabilitation program. It does not replace the specific protocols of each center and must be adapted to local circumstances.

Table 44 . Guideline for the Initial Assessment of Complex Patients

Area of Assessment	Items to Monitor
Cardiology	Primary diagnosis, ejection fraction, NYHA class, known arrhythmias, implantable devices, current treatment
Surgical/Interventional	Type of procedure, date of procedure, postoperative complications, specific active precautions
Metabolic	Glycemic status, renal function, lipid profile, body weight, and recent changes in body weight
Functional	6-minute walk test or equivalent, grip strength, walking speed, activities of daily living
Frailty	Score on a validated scale (e.g., Clinical Frailty Scale), risk of falls
Nutritional	Weight change, signs of cachexia or sarcopenia, approximate dietary intake
Psychosocial	Anxiety and depression symptoms, available social support, barriers to program access
Patient preferences	Personal goals, availability, preferences regarding program type (center-based/home-based/hybrid)

Appendix 2. Ethical and Legal Guidelines for the Rehabilitation of Complex Patients

- **Informed consent and shared decision-making**

For complex patients, particularly frail older adults or those with advanced disease, the process of obtaining informed consent for enrollment in an exercise program must go beyond simply signing a form; it requires a genuine discussion of the expected risks and benefits, tailored to the patient's capacity for understanding—a principle that is, in fact, reflected in the ESC recommendations on risk communication, discussed in other materials in this course.

- **Resuscitation Status and Therapeutic Limits**

For some complex patients, particularly those with advanced heart disease or in the terminal stages of other conditions (e.g., associated advanced cancer), there may be advance decisions regarding the limitation of resuscitation measures. The recovery team must be aware of these decisions before the program begins, as they directly influence the course of action in the event of an acute complication occurring during an exercise session.

- **The Balance Between Patient Autonomy and Risk Protection**

A complex patient who has been properly informed of the risks may legitimately choose to continue an exercise program even in the presence of a risk considered by the medical team to be above average, as long as the decision is made with full knowledge of the facts. The team's role is not to impose a "safer" decision against the expressed will of a competent patient, but to ensure that this decision is truly informed, properly documented, and periodically reassessed.

> **Practical Note:** *Explicitly documenting the discussion of the risks and benefits of the rehabilitation program—not just the final consent—in the patient's medical record protects both the patient and the medical team and is a recommended practice in all complex cases discussed in this manual.*

Appendix 3. Sample Exercise Session Monitoring Form

Filling out such a template at each session—especially during the initial phases of the program for complex patients—allows for tracking progress over time and the early identification of adverse trends that would otherwise be difficult to detect from one isolated session to the next.

Table45 . Sample Exercise Session Monitoring Form

Parameter	**Pre-exercise**	**During exercise (peak)**	**Post-exercise (recovery)**
Heart rate	___ bpm	___ bpm	___ bpm at 2 min
Blood pressure	___ / ___ mmHg	___ / ___ mmHg	___ / ___ mmHg
Peripheral O2 saturation	___ %	___ %	___ %
Borg Scale (perceived exertion)	—	___ / 20	—
Reported symptoms	—	_____	_____
Blood glucose (if applicable)	___ mg/dl	—	___ mg/dl, if indicated

Practical note: *The blank fields in this template must be filled in with actual values measured directly from the patient; an incomplete or carelessly filled-out form provides a false sense of security and cannot replace active clinical monitoring during the session.*

ABBREVIATIONS

Table 46 . Glossary of Abbreviations – Chapter II

Abbreviation	Meaning
ABI	Ankle-brachial index
Borg	Borg Scale of Subjective Perception of Exertion (6–20 or CR10, 0–10)
BP	Blood pressure
CABG	Coronary Artery Bypass Grafting – aortocoronary bypass
COPD	Chronic Obstructive Pulmonary Disease
CPET	Cardiopulmonary exercise test
CRT	Cardiac Resynchronization Therapy
CRT-D	Cardiac resynchronization therapy with defibrillator function
EAPC	European Association of Preventive Cardiology
ECG	Electrocardiogram
EF	Ejection Fraction
ESC	European Society of Cardiology – European Society of Cardiology
ET	Standard exercise test (electrocardiographic)
FITT-VP	Frequency, Intensity, Time, Type, Volume, Progression (principle for prescribing physical exercise)
FMT	Foundational Medical Therapy (the 2026 ESC Guidelines on Heart Failure)
HER2	Human Epidermal Growth Factor Receptor 2 – human epidermal growth factor receptor 2 (a target for certain cancer therapies)
HFpEF	Heart Failure with Preserved Ejection Fraction (EF ≥ 50%)
HFrEF	Heart Failure with Reduced Ejection Fraction (EF < 50%, according to the 2026 ESC guidelines)
HR	Heart Rate
HRR	Reserve heart rate (peak heart rate – resting heart rate)
HT/HBP	Hypertension/High Blood Pressure
ICD	Implantable Cardioverter-Defibrillator – implantable cardioverter-defibrillator
ISWT	Incremental Shuttle Walk Test
LVAD	Left Ventricular Assist Device
MET	Metabolic Equivalent of Task – metabolic equivalent (1 MET ≈ 3.5 mL O_2/kg/min)
NYHA	New York Heart Association – functional classification of heart failure
PAD	Peripheral Artery Disease
Peak VO_2	Peak oxygen consumption—the highest value of oxygen consumption reached during a cardiopulmonary exercise test (ml/kg/min)
RER	Respiratory Exchange Ratio – respiratory exchange ratio (VCO□/VO□)
SpO_2	Peripheral oxygen saturation

Abbreviation	Meaning
SPPB	Short Physical Performance Battery – short physical performance assessment battery
TAVI	Transcatheter Aortic Valve Implantation
TEER	Transcatheter Edge-to-Edge Repair – percutaneous "edge-to-edge" repair of the mitral valve
VCO2	Carbon dioxide production
VE	Minute ventilation
VE/VCO_2	Slope of the CO_2 ventilatory equivalent—an indicator of ventilatory efficiency
VO_2	Oxygen consumption
VT1	First ventilatory threshold (aerobic/anaerobic threshold)
VT2	Second ventilatory threshold (respiratory compensation point)

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CHAPTER III. LEFT VENTRICULAR PERFORMANCE—THE TARGET OF CARDIOVASCULAR RECOVERY

Laura Crăciun

1. INTRODUCTION

- **Definition of the Concept of Left Ventricular Performance**

Left ventricular performance refers to the ability of the left ventricle to fulfill its pumping function—that is, to ensure a cardiac output adequate to the body's metabolic needs, both at rest and during exercise, with filling pressures that do not cause pulmonary congestion. This concept goes beyond the simple measurement of the ejection fraction and includes factors such as intrinsic myocardial contractility, ventricular compliance, synchrony of contraction, and the ability to adapt to variations in preload and afterload.

In current clinical practice, left ventricular performance is often simplified to the echocardiographically measured ejection fraction. This manual is based on the premise that, although the ejection fraction remains an essential and readily available parameter, a complete understanding of LV performance requires the integration of multiple dimensions—structural, functional, and exercise reserve—a central aspect of practice in the field of cardiovascular rehabilitation.

- **Why Left Ventricular Function Is the Cornerstone of Cardiovascular Rehabilitation**

The vast majority of cardiovascular conditions for which patients are referred for rehabilitation—coronary artery disease, myocardial infarction, valvular heart disease, and cardiomyopathies—share a common pathophysiological element that, directly or indirectly, impacts left ventricular performance. The patient's exercise capacity—the primary parameter monitored and optimized through a rehabilitation program—is fundamentally determined by the functional reserve of the left ventricle, along with peripheral factors discussed in detail in the following chapters.

From this perspective, cardiovascular rehabilitation can be viewed, in simplified educational terms, as the set of interventions—such as physical exercise, risk factor management, and therapeutic optimization—aimed at protecting, maintaining, or, when possible, improving left ventricular performance, with a direct effect on the patient's functional capacity, quality of life, and long-term prognosis.

- **Objectives :**
  - to describe the physiological determinants of left ventricular performance and how they are affected in major cardiovascular diseases;
  - to interpret the main echocardiographic, biological, and functional parameters used to assess LV function;
  - to explain the mechanisms by which physical exercise influences left ventricular remodeling;
  - actively participating in the initial assessment, exercise prescription, and monitoring of patients in a cardiovascular rehabilitation program;
  - recognizing signs of deterioration in LV function during a rehabilitation program and taking appropriate action in such situations;
  - completing the standard worksheets used in the unit's practice and accurately documenting the work performed.

The chapter is structured into two main sections:

- ✓ theoretical section—dedicated to the physiology, pathophysiology, and principles of assessment and intervention focused on cardiac performance
- ✓ practical section—dedicated to the practical organization of the cardiovascular rehabilitation program, patient monitoring, and the tools currently used in the department.

- **A Brief History of the Concept in Cardiovascular Rehabilitation**

Cardiovascular rehabilitation programs from the 1960s–1970s were initially designed as simple protocols for progressive mobilization following myocardial infarction, without an explicit conceptual link to v ventricular function. Studies from the 1980s and 1990s provided the first solid evidence regarding the safety and benefits of physical training in patients with documented ventricular dysfunction, and subsequent research, focused on the central and peripheral mechanisms of exercise, has led to the current, integrated understanding of rehabilitation as an intervention that acts directly on the determinants of cardiac performance, not merely on symptoms.

Table 47 . General structure of a ventricular performance-oriented program

Program Component	**Relationship to left ventricular performance**
Initial assessment	Establishes the baseline level of left ventricular function and guides risk stratification
Aerobic exercise	Acts through central and peripheral mechanisms
Resistance training	Predominantly peripheral effect, with an indirect impact on overall functional capacity
Risk factor control	Reduces chronic post-load and limits the progression of pathological remodeling
Optimized pharmacological treatment	Acts synergistically with exercise to promote reverse remodeling

2. PHYSIOLOGY OF LEFT VENTRICULAR FUNCTION

- **The cardiac cycle and determinants of left ventricular performance**

Left ventricular performance is determined by four fundamental physiological factors, whose interactions establish, at any given moment, stroke volume and cardiac output: preload, afterload, myocardial contractility, and heart rate. Understanding these four determinants is essential for correctly interpreting both ventricular dysfunction and the effects of physical exercise on it.

Table 48 . Determinants of left ventricular performance

Determinant	Definition	Relevance to recovery
Preload	The degree of myocardial fiber stretching at the end of diastole, dependent on ventricular filling volume	Aerobic exercise increases venous return and, over time, can improve ventricular compliance
Post-systole	The resistance the ventricle must overcome to eject blood (determined primarily by peripheral vascular resistance)	Blood pressure control and aerobic training reduce chronic afterload
Contractility	The intrinsic ability of the myocardium to contract, independent of preload and afterload	May be irreversibly reduced after a heart attack; exercise acts primarily through other mechanisms
Heart rate	The number of ventricular contractions per minute	Together with stroke volume, it determines cardiac output; adaptation to exercise is frequently impaired in heart disease

The relationship between these determinants is classically described by Frank-Starling's law, according to which, within physiological limits, an increase in preload leads to an increase in contractile force and, consequently, in stroke volume. In patients with advanced ventricular dysfunction, this relationship is altered; the Frank-Starling curve is shifted to the right and flattened, such that further increases in preload no longer result in a proportional increase in pumping performance but, on the contrary, lead to pulmonary congestion.

- **Ejection Fraction—Significance, Calculation, and Limitations of Interpretation**

The left ventricular ejection fraction represents the percentage of the end-diastolic volume that is ejected during systole; it is most commonly calculated via echocardiography as the ratio of the stroke volume (the difference between the end-diastolic volume and the end-systolic volume) to the end-diastolic volume. Although it is the most widely used parameter in clinical practice for characterizing left ventricular systolic function, the ejection fraction has significant limitations in interpretation, which the cardiovascular rehabilitation practitioner must be aware of.

- The ejection fraction depends on loading conditions (preload, afterload) at the time of measurement, not just on intrinsic contractility;
- A preserved ejection fraction does not rule out significant diastolic dysfunction, as is the case in HFpEF;
- Inter- and intra-observer variability in echocardiographic measurements is clinically relevant, which is why a small change in EF between two successive evaluations should be interpreted with caution.

Practical Note: *A useful principle is not to treat the ejection fraction as an absolute number, but to always interpret it in relation to the clinical context, its evolution over time, and, when possible, complementary parameters such as global longitudinal strain.*

A few common pitfalls in the practical interpretation of ejection fraction deserve explicit mention: overestimation of EF in a tachycardic patient, in whom reduced diastolic filling time may influence the measurement using the Simpson method; underestimation of EF in the presence of a suboptimal echocardiographic window, with incomplete visualization of the endocardium; interpreting a "borderline" EF (e.g., 49–52%) as definitively normal or abnormal, without taking into account the method's margin of error; and ignoring regional asymmetry in contractility (segmental hypokinesis or akinesis), which may coexist with an apparently normal global EF.

- **Training-induced physiological remodeling—"athlete's heart"**

Regular physical exercise, of sufficient intensity and volume, induces adaptive structural and functional cardiac changes in healthy individuals, generically known as the "athlete's heart": moderate ventricular dilation, proportional to the increase in muscle mass, often associated with mild ventricular wall hypertrophy, but with preservation or even improvement of systolic and diastolic function. These changes are completely reversible upon cessation of training and must be clearly distinguished from irreversible pathological remodeling.

- **Diastolic Function—Determinants and Relevance to Overall Performance**

Left ventricular performance is not limited to systolic function (the ability to eject blood) but equally includes diastolic function—the ventricle's ability to actively relax and passively fill at normal filling pressures. Active, energy-dependent relaxation and passive compliance of the ventricular wall are the two main determinants of diastolic function; both can be affected independently of systolic function, a situation characteristic of HFpEF.

- **Ventricular Interdependence and the Role of the Right Ventricle**

Although this chapter focuses on left ventricular performance, it is important to note the concept of ventricular interdependence: the two ventricles, separated by the interventricular septum and surrounded by the pericardium, influence each other mechanically. Significant right ventricular dysfunction, secondary to chronic pulmonary hypertension or other causes, can limit left ventricular filling and, indirectly, its ability to generate an adequate cardiac output during exercise—a factor relevant to the correct interpretation of functional limitations in some complex patients.

- **The Cellular Basis of Myocardial Contraction**

At the cellular level, myocardial contraction results from the interaction between actin and myosin filaments in the sarcomere, triggered by the release of calcium from the sarcoplasmic reticulum in response to depolarization of the cell membrane. Efficient excitation-contraction coupling, as well as rapid calcium reuptake during the relaxation phase (essential for the diastolic function discussed earlier), depend on the integrity of regulatory proteins such as troponin and phospholamban. In heart failure, the disruption of intracellular calcium homeostasis represents one of the central molecular mechanisms of contractile dysfunction, which is the focus of some current therapeutic research.

Practical Note: *Understanding this cellular basis helps us understand why myocardial dysfunction may be present—and, in part, reversible—even in the absence of irreversible structural loss of cardiomyocytes—a situation relevant, for example, to "hibernating myocardium," which is discussed in the context of chronic coronary artery disease.*

The concept of hibernating myocardium describes a myocardial region with chronically reduced coronary perfusion but that remains viable, which adaptively reduces its contractile activity to protect long-term cellular survival. Unlike scar tissue, which is irreversibly non-contractile, the hibernating myocardium can resume its contractile function after revascularization, and its identification using

specific imaging techniques to assess myocardial viability can significantly influence both the therapeutic decision (the appropriateness of revascularization) and realistic expectations regarding the evolution of the ejection fraction throughout the recovery program.

Table 49 . Guideline reference values for key VS performance parameters

Parameter	**Guideline Normal Value**	**Remarks**
Ejection Fraction (Simpson biplane)	52–72% (men), 54–74% (women)	Values vary slightly depending on the measurement method and reference population
Global longitudinal strain	approximately -18% to -22%	More negative values indicate better systolic function; indicative threshold for abnormality is above -16%
NT-proBNP	< 125 pg/ml (except in acute heart failure)	Values increase significantly with age and in the presence of renal dysfunction
Peak VO2	Varies with age, sex, and fitness level	Typically interpreted as a percentage of the predicted value for age and sex

Practical note: *The reference values above are strictly for guidance and educational purposes; the correct interpretation of any individual parameter must always be based on the reference values specific to the laboratory or equipment used, as well as on the patient's complete clinical context.*

Summary: *Left ventricular performance is the result of the interaction between preload, afterload, contractility, and heart rate, with ejection fraction remaining the central—but insufficient—parameter for its assessment. Diastolic function, ventricular interdependence, and the distinction between exercise-induced physiological remodeling and pathological remodeling represent additional conceptual landmarks that are essential for a comprehensive understanding of this field.*

3. PATHOPHYSIOLOGY OF LEFT VENTRICULAR FUNCTION

- **Pathological Remodeling Following Myocardial Infarction**

Following a myocardial infarction, the area of necrotic myocardium is progressively replaced by non-contractile fibrous tissue. The left ventricle responds to this loss of contractile mass through a remodeling process, which involves progressive dilation of the ventricular cavity, a change in its geometry (from the normal elliptical shape to a more spherical shape), and compensatory hypertrophy of the remaining viable myocardium. Initially adaptive, this remodeling becomes, over time, a self-perpetuating pathological process that contributes to the progressive deterioration of left ventricular function, independent of recurrent ischemia.

- **Distinct Mechanisms in HFrEF versus HFpEF**

Heart failure with reduced ejection fraction (HFrEF) is characterized predominantly by the loss of functional cardiomyocytes (post-infarction, in dilated cardiomyopathies) and by eccentric remodeling, with ventricular dilation and decreased global contractility. Heart failure with preserved ejection fraction (HFpEF), in contrast, is dominated by myocardial stiffening and impaired active relaxation (diastolic dysfunction), frequently in the context of chronic hypertension, obesity, diabetes, and aging, with ventricular geometry that is often concentric, not dilated.

Table50 . Comparative Characteristics of HFrEF versus HFpEF

Characteristic	**HFrEF**	**HFpEF**
Ejection fraction	< 50%	≥ 50%
Typical ventricular geometry	Dilation, eccentric remodeling	Concentric hypertrophy, normal/small cavity
Dominant mechanism	Loss of cardiomyocytes, decreased contractility	Myocardial stiffening, diastolic dysfunction
Typical population	Post-infarction, dilated cardiomyopathy	Elderly, hypertensive, obese, frequently women
Exercise response	Documented improvement in functional capacity; reverse remodeling possible	Improvement in functional capacity, mechanisms partly peripheral

- **The role of neurohormonal activation in the progression of dysfunction**

A decrease in left ventricular ejection fraction (LVEF) activates, via baroreceptor mechanisms, the sympathetic nervous system and the renin-angiotensin-aldosterone system (RAAS), in an initial compensatory effort aimed at maintaining blood pressure and organ perfusion. However, chronic, sustained activation of these systems has adverse long-term effects—excessive vasoconstriction, fluid and salt retention, and direct toxic effects of catecholamines on the myocardium—contributing to a vicious cycle that accelerates pathological remodeling and the decline in LV function. This pathophysiological understanding underpins both modern pharmacological treatment of heart failure and some of the beneficial effects of physical training, which help rebalance this neurohormonal tone.

Practical Note: *Understanding this neurohormonal vicious cycle is essential for grasping why modern treatment of heart failure—and, complementarily, physical exercise—deliberately aims to "calm" sympathetic activation and the renin-angiotensin-aldosterone system (RAAS), rather than merely providing immediate symptomatic relief.*

- **Geometric Patterns of Ventricular Remodeling**

Left ventricular remodeling can be classified, based on echocardiographic findings, according to the relationship between wall thickness and cavity size, into four main geometric patterns, each with distinct pathophysiological and prognostic implications.

Table51 . Geometric patterns of left ventricular remodeling

Geometric pattern	Characteristics	Typical clinical context
Normal geometry	Normal wall thickness and cavity size	Absence of significant structural heart disease
Concentric remodeling	Increased wall thickness, normal/reduced cavity, normal ventricular mass	Early stages of pressure overload
Concentric hypertrophy	Increased wall thickness, increased ventricular mass, normal/reduced cavity	Chronic hypertension, aortic stenosis
Remodeling/eccentric hypertrophy	Dilated cavity, normal or reduced wall thickness relative to dilation	Post-myocardial infarction, dilated cardiomyopathy

- **The role of myocardial fibrosis**

In addition to the direct loss of cardiomyocytes, myocardial fibrosis—both **cicatricial**, which replaces necrotic areas, and **diffuse, interstitial** fibrosis—contributes significantly to myocardial stiffening and impairs both systolic and diastolic function. Diffuse fibrosis is particularly relevant in HFpEF, where it may be present in the absence of any documented ischemic event and is associated with aging, chronic hypertension, and low-grade systemic inflammation.

Summary: *Left ventricular dysfunction has different pathophysiological mechanisms in HFrEF (loss of cardiomyocytes, eccentric remodeling) and HFpEF (myocardial stiffening, diastolic dysfunction, often concentric remodeling), with both forms being perpetuated by chronic neurohormonal activation and myocardial fibrosis—key elements for understanding the therapeutic role of physical exercise in both conditions.*

- **A Special Case: Stress Cardiomyopathy (Takotsubo)**

Stress cardiomyopathy, also known as Takotsubo syndrome, is a specific, usually transient form of acute left ventricular dysfunction, typically triggered by intense emotional or physical stress, and more common in postmenopausal women. It is characterized by the onset of severe ventricular dysfunction, with complete or nearly complete recovery of the ejection fraction within a few weeks, in the absence of significant coronary obstruction. Although most patients make a full recovery, some may develop severe acute complications, and the decision to enroll a patient in a rehabilitation program must be individualized, taking into account the stage of myocardial recovery the patient is in at the time of evaluation.

- **The Natural History of Untreated Ventricular Dysfunction**

Understanding the natural history of left ventricular dysfunction in the absence of appropriate therapeutic intervention underscores the priority of early enrollment of eligible patients in a rehabilitation program, alongside optimized pharmacological treatment.

Table 52 . The natural history of untreated left ventricular dysfunction

Stage of progression	Typical characteristics, in the absence of intervention
Early, asymptomatic	Systolic or diastolic dysfunction present but compensated, with no overt symptoms
Symptomatic, stable	Onset of exertional dyspnea, progressive limitation of functional capacity
Recurrent decompensations	Repeated episodes of fluid retention, frequent hospitalizations
Advanced, refractory	Symptoms at rest, possible cardiac cachexia, severely poor prognosis

Practical note: *Therapeutic intervention, including a physical exercise component, has the greatest potential to favorably alter the course of this disease when initiated in the early stages or upon stabilization of decompensation, not just in the advanced stages of the disease.*

4. METHODS FOR EVALUATING LEFT VENTRICULAR PERFORMANCE

- **Echocardiography—ejection fraction and global longitudinal strain**

Echocardiography remains the first-line test for assessing LV function, as it is widely available, noninvasive, and reproducible. In addition to the ejection fraction, most commonly calculated using the Simpson biplane method, assessment via global longitudinal strain (GLS)—a technique based on speckle tracking—provides a more sensitive measure of systolic function, capable of detecting subclinical dysfunction before a decline in the ejection fraction, which is relevant, for example, in monitoring cardiotoxicity associated with cancer treatments.

- **Biomarkers: natriuretic peptides**

B-type natriuretic peptide (BNP) and the N-terminal fragment of pro-BNP (NT-proBNP) are released by the ventricular myocardium in response to wall stretching secondary to increased filling pressures. The levels of these biomarkers generally correlate with the severity of ventricular dysfunction and have both diagnostic value—in the initial evaluation of dyspnea of unknown cause—and prognostic value; their changes over time can be used, in conjunction with other parameters, to monitor the response to therapeutic interventions, including the rehabilitation program.

- **Cardiopulmonary Exercise Testing (CPET)—Peak VO_2 as a Functional Benchmark**

Maximal oxygen consumption (peak VO_2), measured by cardiopulmonary exercise testing, represents the integrated functional expression of cardiac performance, pulmonary function, and peripheral muscle oxidative capacity. In patients with heart failure, peak VO_2 has independent prognostic value, often superior to ejection fraction alone, and is widely used for both risk stratification and the individualized prescription of exercise intensity and physic .

- **Cardiac Magnetic Resonance Imaging—Role in Advanced Evaluation**

Cardiac magnetic resonance imaging provides a highly accurate assessment of ventricular volumes and ejection fraction and, in addition to echocardiography, allows for the characterization of myocardial tissue (fibrosis, edema, infiltration) through techniques such as gadolinium late enhancement. Although less readily available in routine practice in the rehabilitation unit, cardiac magnetic resonance imaging plays an important role in determining the etiology of ventricular dysfunction in selected cases, influencing treatment decisions and, indirectly, the rehabilitation strategy.

Table 55. Classification of heart failure based on ejection fraction

Category	Ejection Fraction	Name
HFrEF	< 50%	Heart failure with reduced ejection fraction
HFpEF	≥ 50%	Heart failure with preserved ejection fraction

- **Three-dimensional echocardiography and other advanced techniques**

Three-dimensional echocardiography allows for a more precise quantification of ventricular volumes without relying on the geometric assumptions required by classical two-dimensional methods (such as the Simpson method), thereby reducing some of the measurement variability discussed earlier. Stress echocardiography, performed during or immediately after an exercise test, can be useful for assessing left ventricular contractile reserve—information that complements the resting ejection fraction and is particularly relevant in patients on the borderline between HFrEF and HFpEF.

Table 53 . Comparative overview of assessment methods

Method	Accessibility	Key information provided	Limitations
Standard echocardiography	Very broad, first-line	Ejection fraction, dimensions, associated valvular diseases	Depends on the acoustic window and the operator's experience
Global longitudinal strain	Growing in use, dependent on equipment	Subclinical systolic function, more sensitive than EF	Requires dedicated software; variability across platforms
Biomarkers (BNP/NT-proBNP)	Wide range, simple lab test	Elevated filling pressures, overall severity	Influenced by age, renal function, obesity
Cardiopulmonary exercise testing	Moderate, requires specialized equipment	Peak VO2, ventilatory threshold, integrated functional capacity	Requires trained personnel, more time
Cardiac magnetic resonance imaging	Limited, specialized centers	Tissue characterization, high-accuracy volumes	High cost, limited availability, specific contraindications

- **The Role of Serial Reassessment in Rehabilitation Practice**

Beyond the value of a single measurement, the evolution of these parameters over time—systematically compared with previous assessments of the same patient—provides the most relevant information for practice in the rehabilitation setting. A stable ejection fraction, even if reduced, may represent a favorable outcome in a patient with advanced disease, while a decline—even a modest one—in a previously stable parameter may constitute an important early warning sign.

Summary: *A comprehensive assessment of left ventricular function combines echocardiography (ejection fraction, global longitudinal strain), biomarkers (BNP/NT-proBNP), cardiopulmonary exercise testing (peak VO_2), and, in selected cases, cardiac magnetic resonance imaging—none of these methods, taken in isolation, is sufficient for a complete characterization, and the change in these parameters over time is often more informative than a single measurement.*

5. THE EFFECTS OF PHYSICAL TRAINING ON LEFT VENTRICULAR REMODELING

- **Central mechanisms: the effect of exercise on ejection fraction and reverse remodeling**

In a significant proportion of patients with stable HFrEF, regular aerobic exercise, conducted over periods of at least 8–12 weeks, has been associated with the phenomenon of reverse remodeling—a reduction in ventricular volumes and, in some patients, an improvement in ejection fraction—although the magnitude of this effect is variable and less predictable than the peripheral effects of exercise, which are discussed below. Proposed mechanisms include reduced sympathetic tone, improved coronary endothelial function, and reduced arterial stiffness, with a consequent decrease in chronic afterload.

- **Peripheral mechanisms: skeletal muscle and endothelial function**

An important, often underestimated aspect of the benefits of physical training in patients with left ventricular dysfunction does not occur at the central cardiac level, but rather at the peripheral level: improved muscle capillary density, an increase in the proportion of oxidative muscle fibers, and improved mitochondrial function and endothelial function of peripheral vessels. These peripheral adaptations explain, at least in part, why many patients report a significant improvement in exercise tolerance even in the absence of a measurable change in ejection fraction.

- **Clinical evidence regarding the effect of exercise on ejection fraction and cardiovascular mortality**

Clinical studies and meta-analyses focusing on physical training in heart failure with reduced ejection fraction consistently support improvements in functional capacity and quality of life, as well as a reduction in the rate of hospitalization for heart failure. The effect on all-cause mortality is less pronounced in global analyses but remains favorable, especially in patients with good long-term adherence to the exercise program—a finding that underscores the importance of the educational component and long-term maintenance of the cardiovascular rehabilitation program.

> **Practical Note:** *The benefit of physical training on exercise capacity and quality of life is substantial and quickly apparent, even though a measurable improvement in ejection fraction may not occur in all patients or may require several months of consistent training.*

- **The dose-response relationship between training volume and functional benefit**

Available data suggest a dose-response relationship between the total volume of exercise performed (the product of frequency, duration, and intensity, accumulated over time) and the magnitude of the functional benefit obtained, at least up to a certain threshold, beyond which additional benefits become marginal and the risk of overexertion increases. This observation underscores the importance of sustained adherence to the program, rather than seeking maximum intensity in a small number of sessions.

Table 54 . Summary of Clinical Evidence by Type of Intervention

Type of intervention	Documented effect on functional capacity	Documented effect on EF / remodeling
Moderate, continuous aerobic training	Consistent, well-documented improvement	Modest improvement, varying across studies
High-intensity interval training	Superior improvement in peak VO2 in selected patients	Data suggestive of a superior effect; requires large-scale confirmation
Strength training, combined with aerobic training	Additional improvement in strength and functional autonomy	Limited direct effect; predominantly peripheral benefit

Summary: *Physical exercise influences left ventricular performance both through central mechanisms (reverse remodeling, reduction of chronic afterload) and, perhaps even predominantly, through peripheral mechanisms (muscle function, endothelial function), with a dose-response relationship between the accumulated training volume and the functional benefit obtained, up to a threshold beyond which additional benefits become marginal.*

6. GENERAL PRINCIPLES FOR PRESCRIBING PHYSICAL EXERCISE BASED ON LEFT VENTRICULAR PERFORMANCE

- **FITT Principles Adapted to the Goal of Ventricular Performance**

Exercise prescription for patients whose goal is to maintain or improve LV function must be based on the same FITT principles (Frequency, Intensity, Time, Type) discussed within the general framework of cardiovascular rehabilitation, but with particular attention to intensity—the factor with the greatest influence on the balance between the benefits of remodeling and the risk of overloading an already compromised ventricle.

- **Continuous Aerobic Training versus Interval Training—Differential Effects on Remodeling**

Moderate-intensity continuous aerobic exercise is the standard form of exercise, with a well-documented safety profile, for patients with left ventricular dysfunction. High-intensity interval training (HIIT), in selected, stable patients with low-to-moderate risk, has been associated in some studies with a greater improvement in peak VO_2 and, in some patients, with more pronounced effects on reverse remodeling, compared to continuous training with the same total caloric load, although the response is heterogeneous, and HIIT should not be generalized to all patients, especially those outside the low-to-moderate risk categories discussed in Chapter 2, which is dedicated to complex cases.

- **The Role of Resistance Training**

Light-to-moderate-intensity resistance training does not primarily aim to directly improve central left ventricular (LV) performance, but it significantly contributes to improving peripheral muscle function and combating sarcopenia, which is common in patients with chronic heart failure, with an indirect but relevant effect on overall functional capacity and quality of life.

- **Prescribing Exercise for Patients with Severely Reduced Ejection Fraction**

In patients with severely reduced ejection fraction (typically below 25–30%), exercise prescription must be particularly cautious: short, low-intensity sessions with slow progression, ideally guided by cardiopulmonary exercise testing, with careful monitoring for signs of decompensation. For this category of patients, a realistic goal of the program may be the maintenance or modest improvement of functional capacity and independence, rather than significant structural remodeling of the ventricle.

Table 55 . Exercise intensity zones – comparative reference

Intensity zone	% of reserve heart rate	Equivalent Borg score (6–20)	Typical use
Very light	< 30%	6–9	Warm-up, recovery, Phase I post-acute event
Light to moderate	30–50%	10–11	Initiation of the program for high-risk or frail patients
Moderate	50–70%	12–13	Standard zone for continuous aerobic training
Intense	70–85%	14–16	High-intensity component of interval training
Very intense	> 85%	17–19	Reserved for low-risk patients, under close supervision

- **Progression of the physical training program during Phase II of recovery**

A general periodization framework, applicable to most patients with stable ventricular dysfunction, involves an initial 2–3-week period at a mildto moderate intensity, dedicated primarily to initial adaptation and building the patient's confidence, followed by a period of gradual progression in intensity and duration over 4–6 weeks, and a final consolidation phase, in which a sustainable maintenance level is established, preparing for the transition to Phase III.

Table 56 . Specific contraindications for exercise types, based on the severity of dysfunction

Type of exercise	**Relative contraindication for severe dysfunction**
High-intensity interval training (HIIT)	Severely reduced ejection fraction, recent ventricular arrhythmias, hemodynamic instability
High-load resistance exercises	Severe pulmonary hypertension, significant associated right ventricular dysfunction
Prolonged isometric exercises	Severe ventricular dysfunction, generally avoided in all high-risk categories due to acute postpartum increase
Exercises in a reclined or inverted position	Decompensated or recently stabilized heart failure, due to a sudden increase in preload

Summary: *Exercise prescription focused on left ventricular performance combines the classic FITT principles, careful selection of the type of training (continuous versus interval) based on the severity of dysfunction, systematic use of intensity zones as a common reference point between heart rate and the Borg scale, and gradual periodization of the program throughout Phase II.*

7. ORGANIZATION OF ACTIVITIES IN THE RECOVERY UNIT

- **The Structure of the Multidisciplinary Team and the Role of the Student Intern**

The cardiovascular rehabilitation unit typically operates with a team consisting of a cardiologist, a physical therapist, a nurse, a nutritionist, and, when necessary, a clinical psychologist. The master's student on clinical rotation is integrated into this team in an active but supervised role: they participate in the initial assessment, assist during exercise sessions, help complete documentation, and, gradually, under the direct guidance of the coordinating physical therapist, may take on tasks involving the direct monitoring of patients.

- **Targeted competencies in the rehabilitation department**

Assessment and Monitoring

- recognition of clinical signs of cardiovascular instability;
- participating in the measurement and interpretation of monitoring parameters (heart rate, blood pressure, oxygen saturation, Borg scale);
- applying the pre-session checklist and identifying situations in which the session should be postponed;
- performing routine functional tests (6-minute walk test, SPPB, TUG, grip strength, walking speed) and interpreting the results;
- participating in the measurement of the ankle-brachial index and the assessment of the claudication distance;
- recognizing signs of decompensated heart failure (rapid weight gain, edema, worsening dyspnea);
- identifying warning signs specific to each vascular territory (coronary, cerebrovascular, peripheral).

Exercise Testing and Prescription

- assisting with exercise testing and understanding how to use the results in prescribing exercise;
- understanding the concept of a safety threshold and how to determine training intensity;
- applying the FITT-VP principles when structuring a training session;
- adapting exercises based on comorbidities, age, frailty, and implanted devices (CRT, ICD, LVAD);
- applying training progression based on clinical response and the Borg scale.

Safety and Emergency Protocol

- knowing the criteria for stopping exercise;
- applying the escalation protocol when warning signs appear;
- knowing the location and how to use emergency equipment (defibrillator, oxygen source, emergency kit);
- participating in basic life support maneuvers and understanding the resuscitation algorithm;
- recognizing the risks associated with antithrombotic therapy (bleeding risk, management in case of trauma).

Communication and Education

- effective and empathetic communication with the patient, including in situations of exercise-related anxiety;
- educating patients on self-monitoring (daily weight, blood pressure, symptoms) and recognizing warning signs;
- using the teach-back technique to verify understanding of the information provided;
- basic counseling on smoking cessation and lifestyle changes;
- adapting communication to older patients, those with cognitive impairment, or those with aphasia;
- Involving the family in the recovery process.

Documentation and Teamwork

- accurately and completely filling out the department's standard worksheets;
- explicitly documenting the rationale for prescriptions and events that occurred during the session;
- structured transmission of information to the coordinating physician and other team members;
- interdisciplinary collaboration (physician, physical therapist, nurse, dietitian, psychologist);
- maintaining the confidentiality of patient data and adhering to professional ethics standards.

- **Daily Workflow in the Department**

A typical day of practice begins with reviewing the list of scheduled patients and consulting their records (diagnosis, program phase, any recent changes in clinical status) together with the coordinating physical therapist. This is followed by a quick pre-session assessment of each patient (vital signs, recent symptoms), the actual exercise sessions with continuous monitoring, and, finally, the completion of monitoring forms and a team discussion of any relevant observations.

Table 57 . Indicative daily workflow in the recovery unit

Approximate time interval	**Activity**
8:00–8:30	Handoff, review of scheduled patients and any events from the previous day
08:30–09:00	Quick pre-consultation assessment of patients in the first group (vital signs, symptoms)
9:00–11:30	Conducting practice sessions, with continuous monitoring
11:30–12:00	Completion of monitoring forms, team case discussions
12:00–13:00	Break
1:00 PM–3:00 PM	Second group of patients; initial assessments of newly admitted patients
3:00–3:30	Final documentation, planning for the next day

Practical Note: *Any decision to modify a patient's schedule or interrupt a session for safety reasons must be immediately communicated to the coordinating physical therapist or the department's on-call physician; such decisions must never be made unilaterally by the student intern.*

Table 61. Detailed Roles of Team Members

Team Member	**Primary responsibility**
Cardiologist	Clinical evaluation, decision to enroll, interpretation of test results, coordination of the overall treatment plan
Lead physical therapist	Prescribing and directly supervising exercise, adapting the program
Nurse	Monitoring of vital signs, administration of treatment, first response in emergency situations
Dietitian	Nutritional assessment and counseling, tailored to cardiac and metabolic status
Clinical psychologist	Assessment and intervention regarding psychosocial factors, when necessary
Master's student	Supervised active participation, documentation, and support for team activities

8. FROM PHASE I TO PHASE III: CARDIOVASCULAR RECOVERY GUIDED BY LEFT VENTRICULAR FUNCTION

- **Phase I – Early Mobilization and Protection of Left Ventricular Function**

In Phase I, which typically takes place during hospitalization, the primary goal regarding left ventricular (LV) function is to avoid overloading a recently compromised ventricle (post-infarction, post-surgical), while simultaneously preventing complications associated with prolonged immobilization, which could negatively affect the patient's future functional capacity through deconditioning. Mobilization is gradual and guided by the patient's symptomatic tolerance, not by a rigid protocol that is identical for all patients.

- **Phase II – Structured Program, Monitoring of Ejection Fraction Progress**

Phase II represents the period during which the principles of exercise prescription are applied in practice, with a progressive increase in exercise intensity. In patients with ventricular dysfunction documented at the initial evaluation, an echocardiographic reevaluation at the end of this phase (or according to the local protocol) allows for the objective assessment of any reverse remodeling and the adjustment of the strategy for Phase III.

- **Phase III – Long-Term Maintenance of Left Ventricular Performance**

The objective of Phase III, from the perspective of left ventricular (LV) function, is to prevent the "loss" of the benefits achieved in Phase II due to the interruption of regular physical activity—a clinically documented phenomenon whereby some of the improvement in functional capacity and, in some patients, reverse remodeling, may progressively diminish in the absence of continued exercise. Maintaining long-term motivation is essential for consolidating these benefits.

Table 58 . Guideline criteria for transitioning between phases

Transition	Guideline criteria for transition
Phase I → Phase II	Hemodynamic stability, absence of active complications, ability to move independently or with minimal assistance
Phase II → Phase III	Completion of the structured program, achievement of a stable functional level, absence of recent adverse events, ability to self-manage exercise
Return to a previous phase	Acute decompensation, major intercurrent complication, prolonged interruption of activity (more than 2–3 weeks)

Table 59 . Documentation required for each phase

Phase	Essential documents
Phase I	Initial assessment form, progressive mobilization plan, specific active precautions
Phase II	Monitoring form for each session, periodic reassessments, adjustments to the treatment plan
Phase III	Discharge form from the supervised program, maintenance recommendations, long-term reassessment plan

Summary: *Each phase of cardiovascular rehabilitation has a specific objective, centered on protecting or improving left ventricular function: avoiding overexertion in Phase I, the structured implementation of the exercise prescription and targeting remodeling in Phase II, and the long-term consolidation of the benefits achieved in Phase III, with the transition between phases guided by explicit clinical criteria, not merely by the passage of a fixed period of time.*

9. MONITORING LEFT VENTRICULAR FUNCTION DURING THE REHABILITATION PROGRAM

9.1. GENERAL CONSIDERATIONS

Table 60 . Parameters to be monitored at each visit

Parameter	Relevance to LV performance
Body weight	Rapid weight gain suggests fluid and salt retention, possibly secondary to impaired left ventricular function
Resting heart rate	A progressive increase may reflect compensatory sympathetic activation
Blood pressure	Extreme values (hypotension or uncontrolled hypertension) directly influence postpartum recovery
Subjective exercise tolerance (Borg score at the same workload)	An increased perception of exertion at a constant workload may precede other signs of decompensation
Symptoms of congestion	Dyspnea, orthopnea, edema—direct signs of impaired cardiac function

- **Warning signs suggestive of impaired left ventricular function**
  - rapid weight gain (more than 2 kg in 1–3 days);
  - worsening of exertional dyspnea or the onset of dyspnea at rest/orthopnea;
  - decreased exercise tolerance compared to previous sessions at the same perceived intensity;
  - the onset or worsening of peripheral edema;
  - new-onset symptomatic hypotension during or after exercise.

- **Periodic Reassessment – Guideline**

A structured reassessment, including at least the clinical parameters listed above and, at regular intervals, an echocardiographic or exercise stress test, is recommended at the end of Phase II and, thereafter, at a frequency adapted to the severity of the underlying disease (e.g., every 6–12 months in stable patients, more frequently in those with severe dysfunction or a recent history of instability).

Practical Note: *Any combination of the warning signs listed above that occurs during an exercise session requires the session to be interrupted and the department's coordinating physician to be promptly notified, regardless of the phase of the program the patient is in.*

Table 61 . Guideline for escalation in the event of warning signs

Severity Level	Example scenario	Action
Mild	Mild increase in subjective dyspnea, with no other signs	Reduce intensity, continue close monitoring, inform the coordinating physical therapist
Moderate	Recent weight gain, new edema, reduced tolerance to usual physical activity	Temporary halt to progression, scheduled clinical reevaluation, inform the department physician
Severe	Severe dyspnea, chest pain, symptomatic hypotension, sustained arrhythmia	Immediate interruption of the session, emergency medical evaluation, activation of the department's emergency protocol

Summary: *Monitoring left ventricular performance throughout the rehabilitation program combines simple clinical parameters, tracked at each visit, with more complex periodic reassessments; prompt recognition of warning signs, followed by the implementation of a clear escalation protocol, is an essential practical skill for the student on clinical rotation.*

9.2. MONITORING FUNCTIONAL PROGRESS AND PHYSICAL ACTIVITY DURING THE REHABILITATION PROGRAM

Beyond the simple clinical parameters discussed in the previous sections, the objective assessment of a patient's functional progress throughout the rehabilitation program requires a broader set of tools, each with its own utility, administration technique, and limitations. This section systematically reviews the main methods for quantifying functional progress and physical activity, grouped by category, ranging from formal exercise tests conducted in a laboratory to simple field-based tools and home monitoring. Choosing the right combination of methods for each patient and each stage of the program is an essential practical skill for the student on clinical rotation.

Table 62 . Categories of Methods for Monitoring Functional Progress

Method Category	Main Examples	Typical Context of Use
Formal exercise tests	Standard exercise test, CPET, stress echocardiography	Initial evaluation, major re-evaluations, risk stratification
Submaximal field tests	6-minute walk test, walking speed, shuttle walk test	Periodic monitoring, patients for whom maximal testing is not necessary or possible
Strength and physical performance tests	Dynamometry, sit-to-stand, SPPB, Timed Up and Go	Elderly and frail patients, fall risk assessment
Subjective perception scales	Borg scale	Used at every session to adjust exercise intensity
Quality-of-life questionnaires	MLHFQ, KCCQ, SF-36/EQ-5D, DASI	Initial assessment and periodic follow-ups, especially in heart failure
Biological parameters	NT-proBNP/BNP, metabolic profile	Periodic reassessments, correlated with clinical status
Home monitoring	Wearable devices, self-monitoring of weight	Phase III, long-term follow-up
Structural reassessment	Serial echocardiography	Major reevaluations, every 6–12 months or as clinically indicated

- **General principles for selecting a monitoring method**

No single monitoring method, taken in isolation, provides a complete picture of the patient's functional progress. Choosing the appropriate combination depends on the phase of the program, the resources available in the unit, the severity of ventricular dysfunction, and the patient's physical and cognitive ability to undergo the respective tests. As a general principle, more complex and costly tests (CPET, stress echocardiography) are reserved for initial evaluations and major reassessments, while simple field instruments and perception scales are used at every session or at short intervals for ongoing monitoring.

Practical note: *If a monitoring method requires resources or time that the unit does not currently have available, it should not be abandoned entirely, but rather used selectively at the most relevant points in the program (e.g., the initial assessment and the end of Phase II), supplemented with simple tools that can be applied at every session.*

A. Formal Exercise Tests

- **Standard Electrocardiographic Exercise Test (ET)**

The standard exercise test, performed on a cycle ergometer or treadmill with continuous electrocardiographic monitoring, is the classic method for assessing functional capacity and detecting exercise-induced myocardial ischemia by monitoring ST-segment changes, the occurrence of arrhythmias, and blood pressure response.

Main indications in cardiovascular rehabilitation:

- determining initial functional capacity (expressed in metabolic equivalents, METs) prior to enrollment in the program;
- assessing risk for supervised exercise;
- determining the target heart rate for the exercise prescription;
- periodically reassessing changes in functional capacity.

Absolute and relative contraindications have been detailed in the manual dedicated to exercise testing (recent acute myocardial infarction, unstable angina, uncontrolled arrhythmias, severe symptomatic aortic stenosis, decompensated heart failure, among others) and remain fully applicable to the use of this test for monitoring progress.

The testing technique involves following a standardized protocol with a progressive increase in workload, most commonly one of the following:

Table 63 . Protocols Used in Standard Exercise Testing

Protocol	Characteristics	Typical Use
Standard Bruce	3-minute intervals, relatively large increases in speed and incline	Patients with good functional capacity, low risk
Modified Bruce	Two initial warm-up stages at low workload prior to the standard Bruce protocol	Patients who have recently experienced an acute event, with reduced functional capacity
Naughton	Small steps, slow increments, no slope in the first steps	Patients with heart failure or severely reduced functional capacity
Balke-Ware	Constant speed, gradual increase in incline only	Patients for whom large increases in speed are undesirable

Interpretation of the results is based on several factors: the functional capacity achieved (expressed in METs or test duration, relative to normal values for age and sex), the presence or absence of ST-segment changes indicative of ischemia, the occurrence of significant arrhythmias, the blood pressure response (normal, markedly hypertensive, or hypotensive), and the reason for stopping the test (symptom-limited, reaching the target heart rate, or peripheral muscle fatigue).

Advantages: widely available, low cost compared to CPET, well-standardized technique, extensive experience documented in the literature.

Disadvantages: does not provide direct information about gas exchange or the specific limitation (cardiac versus peripheral/muscular) of exercise capacity; lower sensitivity for detecting ischemia compared to stress imaging tests.

- **Cardiopulmonary Exercise Testing (CPET)**

Cardiopulmonary exercise testing adds to the standard exercise test the direct, breath-by-breath measurement of gas exchange (oxygen consumption, carbon dioxide production, ventilation), providing an integrated assessment of cardiac, pulmonary, and peripheral muscle function that is superior to the standard test for a comprehensive characterization of exercise capacity.
Specific indications, beyond those of the standard test:

- objective assessment of exertional dyspnea of unclear cause, to differentiate between cardiac and pulmonary origins or muscular deconditioning;
- determination of the ventilatory threshold, as the preferred benchmark for prescribing exercise intensity, which is more reliable than heart rate in patients on beta-blocker therapy;
- assessment for major therapeutic decisions (heart transplant, ventricular assist devices), where peak VO_2 has well-established prognostic value.

Contraindications are essentially identical to those of the standard exercise test, with the addition of specific considerations related to the need for patient cooperation with the mask or mouthpiece used to collect exhaled gases.
The testing technique most commonly uses "ramp" protocols, with a continuous, linear increase in workload rather than discrete steps, allowing for a more precise determination of the ventilatory threshold. The patient breathes through a mask or mouthpiece connected to a gas analyzer, and the test is conducted, similar to the standard test, until a symptom-limited endpoint is reached.

Table 64 . Cardiopulmonary exercise testing (CPET) parameters and their interpretation

CPET Parameter	Meaning	Guideline for Interpretation
Peak VO_2	Maximum oxygen consumption achieved	Less than 14 ml/kg/min suggests a poor prognosis in patients with heart failure
Ventilatory threshold (AT)	The intensity at which metabolism becomes predominantly anaerobic	Preferred benchmark for prescribing training intensity
VE/VCO2 slope	Ventilatory efficiency	Values above 35 suggest a more guarded prognosis
Respiratory exchange ratio (RER)	Indicates the effort expended/degree of exhaustion at the end of the test	An RER above 1.10 suggests a true maximal effort
Oxygen pulse (O2 pulse)	A surrogate for stroke volume during exercise	An early plateau may suggest central cardiac limitation

Advantages: integrated functional information, superior prognostic value, objective benchmark for prescribing exercise intensity, useful for differentiating the cause of functional limitation.
Disadvantages: requires specialized equipment and trained personnel, longer assessment time, higher cost, limited availability in many departments.

- **Stress echocardiography**

Stress echocardiography involves acquiring echocardiographic images during or immediately after stress—whether physical (exercise on a cycle ergometer or treadmill) or pharmacological (dobutamine, in patients unable to perform physical exercise)—with the aim of assessing the response of ventricular function to stress and detecting inducible myocardial ischemia or myocardial viability (hibernating myocardium).

Main indications in the context of cardiovascular rehabilitation:

- assessment of left ventricular contractile reserve, particularly in patients with resting dysfunction at the boundary between HFmrEF and HFpEF;
- detection of inducible ischemia in patients with symptoms or equivocal electrocardiographic changes on a standard exercise test;
- assessment of myocardial viability in patients who are candidates for revascularization and have regional ventricular dysfunction.

Contraindications are similar to those of the standard exercise test for the physical exercise variant and include specific precautions related to the pharmacological agent used (e.g., significant arrhythmias, uncontrolled hypertension) for the dobutamine variant.

The procedure involves acquiring echocardiographic images at standardized time points—at rest, at progressive levels of stress, and, in the exercise protocol, immediately post-exercise—with a comparison of segmental and global contractility between these time points. Interpretation focuses on the emergence of new wall motion abnormalities (suggestive of inducible ischemia) or, conversely, the improvement in contractility of hypokinetic segments at rest (suggestive of viability).

Advantages: absence of ionizing radiation; direct, visual assessment of ventricular function under stress; additional information compared to the electrocardiogram alone.

Disadvantages: Dependent on the operator's experience; variable image quality depending on the acoustic window; more limited availability than the standard exercise test.

B. Submaximal Field Tests

- ***6-Minutes Walk* Test** (6MWT*)*

The 6-minute walk test measures the maximum distance a patient can cover by walking (not running) on a flat surface within a 6-minute period, at their own pace, with the option to stop and resume walking if necessary. It is one of the most widely used submaximal functional assessment tools, due to its simplicity, low cost, and relevance to daily activities.

Indications: assessment of functional capacity in patients for whom maximal testing is not available, indicated, or necessary (elderly, frail patients, those with advanced heart failure); monitoring of progress over time; and as a complementary assessment to formal exercise testing.

Contraindications: unstable angina or recent myocardial infarction; as with other forms of exercise testing, the test must be stopped immediately upon the onset of chest pain, severe dyspnea, marked dizziness, or pallor.

The standardized procedure involves a flat path at least 30 meters long, marked at each end; the patient is instructed to cover as much distance as possible in 6 minutes at their own pace, and may slow down or stop if necessary, without stopping the stopwatch. Standardized verbal encouragement is provided at fixed intervals (for example, every minute) to avoid variability introduced by an examiner who is either too encouraging or, conversely, too passive.

The result is interpreted by comparing it to reference values (adjusted for age, sex, height, and weight) and, more importantly for longitudinal monitoring, by comparing it to the same patient's previous assessments. A minimal clinically important difference (MCID) is, as a guideline, approximately 25–30 meters.

> **Practical note:** *When comparing two 6-minute walk tests from the same patient, it is essential that they be performed under conditions that are as similar as possible (the same walking path, the same instructions, the same time of day, if possible), to avoid misinterpreting a methodological variation as a real change in functional capacity.*

Advantages: simple, inexpensive, requires no specialized equipment, well tolerated, reflects daily functional activity.

Disadvantages: influenced by the patient's motivation and the examiner's technique; less sensitive than the CPET for patients with good functional capacity ("ceiling effect").

- **10-Meter Walking Speed Test**

This test measures the time required to walk a distance of 10 meters at a normal pace or, in some versions, at maximum speed, from which walking speed (meters per second) is calculated. It is one of the simplest and most robust indicators of overall functional status, widely used in geriatric and frailty assessments.
Indications: rapid assessment of functional status, a component of frailty assessment, and simple monitoring over time in patients for whom other tests are difficult to administer.
Test procedure: The patient walks a marked distance (usually with an additional 2 meters of acceleration and deceleration at each end, to measure only the central portion at a constant speed), timed by the examiner.
Interpretation: A walking speed below approximately 0.8 m/s is considered a guideline threshold for frailty and increased functional risk, while speeds above 1.0 m/s are generally associated with good functional status.
Advantages: extremely fast, easy to repeat, robust predictor of long-term functional outcomes.
Disadvantages: provides less detailed information than longer walking tests; sensitive to walking surface and type of footwear.

- **Incremental Shuttle Walk Test**

This test involves walking between two cones placed 10 meters apart at a speed dictated by recorded audio cues that increase progressively every minute; the test continues until the patient can no longer maintain the required speed. Unlike the 6-minute walk test, which is self-paced by the patient, this test is more akin to a progressive maximal test.
Indications: an alternative to the 6-minute walk test when a more accurate assessment of maximal capacity is desired; it is also useful for indirectly estimating peak VO2 using conversion formulas.
The test procedure requires an audio device with standardized signals and a marked 10-meter lane; the test is stopped when the patient fails to reach the opposite cone before the audio signal twice in a row, or upon the onset of limiting symptoms.
Advantages: more sensitive to changes in functional capacity in patients with good functional status compared to the 6-minute walk test; good standardization of the prescribed walking speed.
Disadvantages: requires specific audio equipment; more demanding for patients with reduced functional capacity; less studied than the 6-minute walk test in the population with advanced heart failure.

- **Stair-climbing test**

The stair-climbing test, although less standardized than other field tests, is frequently used, especially in the postoperative setting (cardiac or thoracic surgery), to provide a rapid, practical estimate of functional capacity based on the number of steps climbed before the onset of limiting symptoms or the time required to climb a fixed number of steps.
Indications: rapid assessment, at the patient's bedside or on the ward, particularly in Phase I, for patients who have undergone cardiac surgery, for whom a formal exercise test is not yet possible or indicated.
Advantages: requires no specialized equipment; ecologically valid for daily activities (many homes have stairs).
Disadvantages: lack of uniform international standardization, significant variability among the different types of stairs used (step height, presence of handrails).

C. Strength and Physical Performance Tests

- **Grip strength test (hand grip strength)**

The grip strength test measures the maximum muscle force generated by squeezing a handheld dynamometer; it is a simple yet surprisingly robust marker of overall muscle strength and sarcopenia status, with predictive value for functional decline and, in some studies, even for mortality.

The test procedure involves a standardized position (seated, elbow flexed at 90 degrees, forearm in a neutral position), with the patient asked to squeeze the dynamometer with maximum force, typically in three successive attempts for each hand, and the maximum recorded value is noted.
Interpretation: Values are compared to age- and sex-adjusted norms; values below the reference thresholds (which vary depending on the reference population used) are suggestive of sarcopenia and warrant further functional evaluation.
Advantages: extremely fast (a few minutes), inexpensive, reproducible, applicable even to patients with very limited mobility.
Disadvantages: Reflects upper-limb strength, not necessarily that of the lower limbs, which is more relevant for walking; requires a calibrated dynamometer for comparable results over time.

- **Sit-to-Stand Test**

This test assesses the strength and endurance of the lower limb muscles by counting the number of complete stands from a standard chair, without using the arms for support, within a fixed time interval (most commonly 30 seconds), or, alternatively, by timing the duration required to perform 5 consecutive stands.
Indications: rapid assessment of lower limb strength, a component of frailty assessment, and simple monitoring of progress in elderly patients or those with reduced mobility.
Interpretation: The number of stands (or the time required for 5 stands) is compared to normative values adjusted for age and sex; a prolonged time or a reduced number of stands suggests increased functional risk and risk of falling.
Advantages: requires no equipment (only a standard chair), is quick, ecologically valid, and well correlated with daily functioning.
Disadvantages: influenced by individual lifting technique; less sensitive to small changes in muscle strength compared to isokinetic dynamometry.

- **Short Physical Performance Battery (SPPB)**

The SPPB is a composite instrument widely used in geriatric assessment that combines three components—static balance (in progressively more difficult positions), short-distance walking speed, and the chair stand test—each scored on a scale of 0 to 4 points, with the total score (maximum 12 points) providing a composite picture of overall physical performance.

Table 65 . Interpretation of the SPPB Score

SPPB Total Score	Guideline Interpretation
10–12	Good physical performance
7–9	Moderately impaired physical performance
0–6	Severely impaired physical performance, significant functional risk

Advantages: comprehensive assessment, more informative than a single isolated test, well-validated for predicting functional outcomes and the risk of disability.
Disadvantages: takes more time than a simple test; requires minimal equipment (chair, stopwatch, space for balance tests).

- **Timed Up and Go (TUG) Test**

The TUG test measures the time it takes a patient to stand up from a chair with a backrest, walk a distance of 3 meters, turn around, and return to the initial seated position, providing a rapid and comprehensive assessment of functional mobility and the risk of falling.
Interpretation: A time under 10 seconds is considered normal for an independent adult; times over 13–14 seconds are associated with an increased risk of falling and require further evaluation.

Advantages: very fast, requires no specialized equipment, easy to repeat for long-term monitoring.
Disadvantages: Sensitive to footwear type and the use of a walking aid; provides less detailed information than the SPPB.

D. Subjective Perceived Exertion Scales

- **The Borg Scale (6–20) and the Borg CR10 Scale**

The Borg Scale is the standard tool for quantifying the Rating of Perceived Exertion (RPE), designed so that the values on the classic scale (6–20) correspond approximately—when multiplied by 10—to the expected heart rate for that level of exertion in a young, healthy adult (for example, a Borg score of 13 roughly corresponds to a heart rate of approximately 130 beats per minute).

Table 70. The Borg Scale (6–20)—verbal descriptors and corresponding intensity

Borg score (6–20)	Verbal descriptor	Corresponding intensity
6–7	Very, very light	Rest, recovery
8–9	Very easy	Warm-up
10–11	Easy	Light to moderate zone
12–13	Somewhat challenging	Moderate zone, standard for continuous aerobic training
14–15	Challenging	Intense zone
16–17	Very demanding	The most intense part of interval training
18–19	Very, very demanding	Close to maximum effort
20	Maximum effort	Complete exhaustion

An alternative option, the Borg CR10 scale (Category-Ratio, 0–10), is frequently used to quantify specific symptoms, such as dyspnea or pain, offering a more intuitive scale for some patients, with similar verbal anchors but a different numerical range (0 = none, 10 = maximum imaginable).
The practical use of the Borg scale in cardiovascular rehabilitation is twofold: on the one hand, as a tool for prescribing exercise intensity (the patient is guided to maintain effort within a target range on the scale, typically 12–14 for standard aerobic training), and on the other hand, as a tool for monitoring progress—a decrease over time in the Borg score reported for the same objective workload is an indirect but valuable sign of improved functional capacity.

> **Practical note:** *The Borg scale becomes the preferred reference tool, instead of the classically calculated target heart rate, for patients on beta-blocker therapy or those with an atypical chronotropic response to exercise (for example, heart transplant patients, discussed in another module of this course), in whom the relationship between heart rate and actual exercise intensity is altered.*

Advantages: simple, quick, requires no equipment, applicable at every session, particularly useful when heart rate monitoring is unreliable.
Disadvantages: subjective, influenced by the patient's psychological state and familiarity with the scale, requires brief initial training of the patient for correct and consistent use.

E. Quality-of-Life and Functional Status Questionnaires

- **Minnesota Living with Heart Failure Questionnaire (MLHFQ)**

The MLHFQ is a heart failure-specific questionnaire consisting of 21 questions that assesses the impact of the disease on quality of life across three main dimensions—physical, emotional, and

socioeconomic—with the patient rating, on a scale from 0 to 5, the extent to which heart failure has affected their life over the past month. The total score—which is higher when the impact is more negative—allows for monitoring changes in the patient's subjective perception of the disease, complementing objective functional parameters.
Advantages: specific to heart failure, sensitive to changes induced by treatment or rehabilitation programs, widely used, allowing for comparisons with the existing literature.
Disadvantages: takes time to complete and interpret; limited applicability to patients without documented heart failure.

- **Kansas City Cardiomyopathy Questionnaire (KCCQ)**

The KCCQ is another questionnaire specific to heart failure that, similar to the MLHFQ, several domains—symptoms (frequency, severity, recent changes), functional limitation, quality of life, and social impact—and is considered, in recent literature, to be particularly sensitive to clinically relevant changes, which is why it is widely used as a secondary endpoint in modern clinical trials focused on heart failure.
Advantages: high sensitivity to change, a structure that allows for the calculation of a single summary score, and ease of longitudinal tracking.
Disadvantages: requires licensing for certain uses; scoring is somewhat more complex compared to simpler instruments.

- **General Quality-of-Life Questionnaires (SF-36, EQ-5D)**

Unlike heart failure-specific instruments, general questionnaires such as the SF-36 (Short Form 36) or EQ-5D assess health-related quality of life in a way that is applicable to any chronic condition, allowing for comparisons between different patient groups or even with the general population, but with potentially lower sensitivity to specific, subtle changes strictly related to cardiovascular status.
Advantages: broad applicability, comparability across different patient populations, and instruments that are extremely well-validated and well-studied.
Disadvantages: less sensitive to changes specific to cardiovascular disease compared to dedicated instruments such as the MLHFQ or KCCQ.

- **Duke Activity Status Index (DASI)**

The DASI is a short, self-report questionnaire that estimates a patient's functional capacity through questions related to the ability to perform daily activities of known intensity (e.g., personal care, walking varying distances, climbing stairs, household chores, or sexual activity), and the resulting score can be converted, using a validated formula, into an estimate of peak VO2, which is useful when direct exercise testing is not available.
Advantages: extremely quick to complete (12 questions), requires no equipment, provides a useful functional estimate in the absence of formal testing.
Disadvantages: based on self-reporting, susceptible to the patient overestimating or underestimating their actual capacity, less accurate than direct objective testing.

F. Biological Parameters and Biomarkers

- **Natriuretic peptides (NT-proBNP/BNP) in longitudinal monitoring**

Beyond their initial diagnostic role, changes over time in NT-proBNP or BNP levels can serve as a complementary biological marker of response to the recovery program: a decrease in these levels during the program indirectly suggests an improvement in ventricular filling pressures, while a sustained increase may precede other clinical signs of decompensation, serving as an early warning sign.
Advantages: a simple, widely available laboratory test with well-documented prognostic value.
Disadvantages: influenced by numerous confounding factors (age, renal function, obesity, atrial fibrillation), always requiring contextual interpretation, not in isolation.

- **Metabolic profile (lipids, HbA1c, renal function)**

Periodic monitoring of the lipid profile, glycated hemoglobin (in diabetic patients), and renal function does not directly assess ventricular performance or exercise capacity, but provides a complementary, essential picture of how cardiovascular risk factors respond to the recovery program—factors that have a direct impact on chronic postpartum conditions and the progression of the underlying disease.
Advantages: objective information on risk factor control, easily obtained through routine laboratory tests.
Disadvantages: reflects ventricular performance indirectly, not directly; requires correlation with the other parameters discussed in this subsection.

G. Continuous Home Monitoring

- **Wearable devices and accelerometry**

Consumer wearable devices (smart bracelets or watches) and dedicated accelerometers allow for the objective quantification of a patient's daily physical activity level (number of steps, time spent in moderate-to-vigorous activity), providing valuable complementary information to that obtained exclusively from supervised sessions, especially for assessing actual adherence to the Phase III physical activity recommendation.
Advantages: continuous, objective monitoring of daily physical activity beyond formal exercise sessions; may increase patient motivation through immediate visual feedback.
Disadvantages: variable accuracy across devices, particularly for estimating heart rate or calorie expenditure; requires access to technology and, often, an associated mobile app.

- **Self-Monitoring of Body Weight**

Although not, strictly speaking, a method for assessing physical activity, daily self-monitoring of body weight at home is a simple and extremely valuable tool for the early detection of fluid and salt retention, complementing the functional monitoring discussed in this subsection, which is why it is included here as an essential component of the home monitoring panel.
Advantages: extremely simple, inexpensive (requires only a scale), can be performed independently by the patient, with well-documented early warning value.
Disadvantages: requires consistent patient adherence and standardized measurement conditions (same time of day, same clothing) for comparable results.

H. Structural Reassessment

- **Serial Echocardiographic Reassessment**

Periodic repeat echocardiographic evaluation—monitoring ejection fraction, global longitudinal strain (when available), and ventricular volumes—allows for the objective assessment of any reverse remodeling induced by the rehabilitation program, discussed at length in Chapter 5—which, along with TEP, is one of the few methods capable of directly assessing structural changes in left ventricular performance, not just their functional consequences.
The recommended frequency of echocardiographic reevaluation should be tailored to the individual: generally, at the end of Phase II and, subsequently, at 6–12 months in stable patients, and more frequently in those with a recent unstable course or severe dysfunction.
Advantages: direct assessment of cardiac structure and function; noninvasive; repeatable without associated risks.
Disadvantages: higher cost and time requirements than simple functional tests; requires access to an echocardiograph and qualified personnel for interpretation.

Table 66 . Comparative summary of monitoring methods

Method	**What it primarily assesses**	**Approximate frequency of use**	**Complexity/cost**
Standard stress test	Functional capacity, ischemic threshold	Initial assessment, major re-evaluations	Moderate
CPET	Peak VO_2, ventilatory threshold, cardiac vs. peripheral limitation	Initial assessment, selected cases, major reassessments	High
Stress echocardiography	Contractile reserve, ischemia/viability	Selected cases	High
6-minute walk test	Submaximal functional capacity	Periodically, every few weeks to months	Low
10-meter walking speed	Overall functional status, frailty	Periodically, to be repeated quickly	Very low
Shuttle walk test	Functional capacity, closer to maximum	Periodic, alternative to 6MWT	Low
Grip strength test	Overall muscle strength, sarcopenia	Initial and periodic assessment	Very low
Sit-to-stand	Lower-limb strength	Periodically, to be repeated quickly	Very low
SPPB	Composite physical performance	Initial and periodic assessment, especially in older adults	Low
Timed Up and Go	Functional mobility, risk of falls	Initial and periodic assessment	Very low
Borg Scale	Subjective Perception of Exertion	At each session	Very low
MLHFQ / KCCQ	Heart Failure-Specific Quality of Life	Baseline and periodic assessment (e.g., at 3–6 months)	Low
SF-36 / EQ-5D	General quality of life	Initial and periodic assessment	Low
DASI	Indirect Assessment of Functional Status	Initial assessment, when direct testing is not possible	Very low
NT-proBNP/BNP	Preload, overall severity	Periodic assessments, based on clinical status	Moderate
Metabolic profile	Risk factor management	Periodically, according to prevention guidelines	Moderate
Wearable devices	Daily physical activity, adherence	Continuous, especially in Phase III	Low to moderate
Self-monitoring of weight	Fluid retention	Daily, at home	Very low
Serial echocardiography	Cardiac structure and function	Every 6–12 months or as clinically indicated	High

Table 72. Selecting the optimal combination of methods by program phase

Program phase	Recommended priority methods
Phase I	Stair-climbing test or short assisted walk, Borg scale, baseline clinical parameters
Phase II — Initial assessment	Standard exercise test or CPET, 6-minute walk test, dynamometry, quality-of-life questionnaire, baseline biological profile
Phase II — Ongoing monitoring	Borg scale at each session, 6-minute walk test every 2–4 weeks, self-monitoring of weight
Phase II — Final Reassessment	Repeat of the initial exercise test, quality-of-life questionnaire, and, if necessary, echocardiographic reevaluation
Phase III	Wearable devices/accelerometry, self-monitoring of weight, field tests every few months, annual structural reevaluations or as indicated

Practical Note: *The final selection of methods used in each setting should be tailored to available resources, the predominant type of patients treated, and local protocols; the central principle remains the combination of complementary methods, not the exclusive use of a single monitoring method.*

Summary: *Comprehensive monitoring of functional progress and physical activity throughout the cardiovascular rehabilitation program requires a judicious combination of complementary methods—formal exercise tests for major assessments, field tests and perception scales for ongoing monitoring, quality-of-life questionnaires for the subjective dimension of progress, biological parameters for monitoring risk factors, home monitoring for Phase III, and periodic structural reassessments for direct quantification of left ventricular performance. None of these methods is sufficient on its own, and the ability to select and interpret the appropriate combination for each patient is one of the essential practical skills targeted by this training program.*

Conclusion: *Monitoring left ventricular function throughout the rehabilitation program combines simple clinical parameters, assessed at each visit, with more complex periodic reassessments; prompt recognition of warning signs, followed by the implementation of a clear escalation protocol, is an essential practical skill for the student on this rotation.*

10. CHARACTERISTICS OF PATIENTS WITH SEVERE VENTRICULAR DYSFUNCTION

- **Patients with an ejection fraction below 30%**

In patients with an ejection fraction below 30%, the risk of hemodynamic instability and ventricular arrhythmias is significantly higher; for this reason, the exercise program must be conducted under direct, continuous supervision, with short initial sessions and an extremely gradual progression—principles already introduced in the previous chapter but which are worth reiterating here from the practical perspective of clinical : These patients often represent the most instructive cases, but also those that require the greatest vigilance on the part of the team, including the student intern.

- **Patients with Devices (CRT, LVAD) and the Impact on Left Ventricular Performance**

Cardiac resynchronization therapy (CRT) explicitly aims to improve left ventricular function by correcting contraction asynchrony in patients with left bundle branch block and significant ventricular dysfunction, and the response to this therapy can be objectively assessed over time through follow-up echocardiography. Left ventricular assist devices (LVADs), on the other hand, partially or completely take over the pumping function of the native ventricle, and performance parameters must be interpreted differently, taking into account both the residual function of the native ventricle and device-specific parameters.

- **Limitations of Exercise Training in Severe Dysfunction**

In a subgroup of patients with very severe ventricular dysfunction that is refractory to treatment, the realistic goal of the rehabilitation program is no longer significant functional improvement, but rather maintaining a minimum level of autonomy and preventing further deconditioning, with an emphasis on quality of life rather than on objective indicators of cardiac performance—an important distinction to communicate to both the patient and their family.

Table67 . Summary of specific precautions by device type

Device	Intended effect on cardiac output	Specific Precaution for Exercise
CRT	Resynchronization of contraction, improvement in EF in responders	Verification of device programming, assessment of response at 3–6 months
LVAD	Partial/total takeover of pumping function	Monitoring via device parameters; pay attention to the external power supply
ICD (without CRT)	No direct effect on left ventricular (LV) performance; prevention of sudden death	Adherence to the heart rate threshold for arrhythmia detection

Summary: *Patients with severe ventricular dysfunction require an approach with wider safety margins, specific knowledge of the particularities imposed by cardiac devices (CRT, LVAD, ICD) and, in the most advanced cases, a realistic recalibration of program goals, shifting the focus from objective cardiac performance to quality of life and functional autonomy.*

11. CARDIOPROTECTIVE PHARMACOLOGICAL THERAPY AND ITS INTERACTION WITH PHYSICAL EXERCISE

- **Therapies with proven effects on reverse remodeling**

Several therapeutic classes used in the treatment of heart failure with reduced ejection fraction have demonstrated, beyond their symptomatic effects, the ability to induce left ventricular reverse remodeling: angiotensin-converting enzyme inhibitors or angiotensin receptor blockers-neprilysin, beta-blockers specifically indicated for heart failure, mineralocorticoid receptor antagonists, and, more recently, SGLT2 inhibitors. Familiarity with these therapeutic classes—although their prescription is not within the scope of a physical therapist's practice—is useful for understanding the overall therapeutic context of a patient enrolled in a rehabilitation program.

Table 68 . Pharmacological therapies that influence reverse remodeling

Therapeutic class	Mechanism relevant to VS performance
Angiotensin-converting enzyme inhibitors / sacubitril-valsartan	Reduce afterload and RAAS activation, promoting reverse remodeling
Beta-blockers specific to heart failure	Reduce chronic sympathetic tone, with proven long-term anti-remodeling effects
Mineralocorticoid receptor antagonists	Reduce myocardial fibrosis and fluid and salt retention
SGLT2 inhibitors	Mechanism not fully understood; associated with improved remodeling and reduced readmissions

Table 69 . Medication–exercise interactions relevant to the clinician

Therapeutic class	Relevance to rehabilitation practice
Treatment of heart failure (FMT—Foundational Medical Therapy // AMT—Additional Medical Therapy)	
Beta-blockers	Limit the increase in heart rate during exercise; the Borg scale is preferred for determining exercise intensity; target heart rate established solely based on an exercise test performed while on treatment
ACE inhibitors / ARBs / ARNI	Risk of hypotension, especially after exercise and upon initiation or dose increase; mandatory recovery period, without abrupt cessation of exercise; caution during transition to standing position
Mineralocorticoid receptor antagonists	Risk of hyperkalemia; relevant when combined with potassium supplements or a potassium-rich diet, and in cases of dehydration
SGLT2 inhibitors	Mild diuretic effect; pay attention to hydration, especially in hot weather; rare risk of euglycemic ketoacidosis with reduced food intake
Diuretics	Risk of volume depletion and electrolyte disturbances (hypokalemia); be cautious of post-exercise orthostatic hypotension and muscle cramps
Ivabradine	Limits increases in heart rate, similar to beta-blockers; intensity is measured using the Borg scale; possible phosphenes with sudden changes in light intensity
Digoxin	May cause ST-segment depression on exercise testing (false positive for ischemia); limits heart rate; watch for signs of toxicity (nausea, visual disturbances, arrhythmias), especially with hypokalemia

Therapeutic class	**Relevance to rehabilitation practice**
Vericiguat	Risk of symptomatic hypotension; monitor blood pressure before and after the session
Hydralazine + isosorbide dinitrate	Risk of hypotension and headache; gradual recovery after exercise
Antianginal and antiarrhythmic treatment	
Nitrates	Risk of hypotension; sublingual nitroglycerin may be used prophylactically before exercise, as directed by a physician; contraindicated in combination with PDE5 inhibitors (sildenafil, tadalafil)
Calcium channel blockers – dihydropyridines (amlodipine)	Hypotension, leg edema (not to be confused with heart failure decompensation); possible reflex tachycardia
Calcium channel blockers – non-dihydropyridines (verapamil, diltiazem)	Reduce heart rate and contractility; avoid in HFrEF; intensity is gauged using the Borg scale
Amiodarone	Bradycardia and reduced heart rate; photosensitivity during outdoor exercise; new-onset dyspnea may indicate pulmonary toxicity
Antithrombotic therapy	
Antiplatelet agents (aspirin, clopidogrel, ticagrelor, prasugrel)	Increased bleeding risk, mild bruising; avoid exercises with a risk of trauma; ticagrelor may cause dyspnea, which should not be confused with exercise intolerance
Oral anticoagulants (VKAs, NOACs)	Increased risk of bleeding; avoid exercises with a risk of falls or impact; seek prompt medical attention for any trauma, especially head trauma
Lipid-lowering therapy	
Statins	Possible myalgia; differentiate from post-exercise muscle soreness; severe, persistent muscle pain accompanied by weakness or dark-colored urine requires cessation of exercise and measurement of CK
Ezetimibe, PCSK9 inhibitors, bempedoic acid	No significant interactions with exercise; bempedoic acid may increase uric acid levels (risk of gout)
Metabolic treatment	
Insulin and sulfonylureas	Risk of hypoglycemia during and after exercise; check blood glucose before the session; have a carbohydrate snack available; have doses adjusted by a doctor
GLP-1 / GIP-GLP-1 agonists (semaglutide, tirzepatide)	Weight loss with risk of muscle mass loss; resistance training and adequate protein intake are mandatory; nausea and risk of dehydration
Other classes	
Alpha-blockers (doxazosin, tamsulosin)	Increased risk of orthostatic hypotension, especially after exercise and in the elderly

Practical Note: *The student clinician does not adjust pharmacological treatment but must recognize its effects on the exercise response in order to correctly interpret the monitored parameters and report any unusual discrepancies between them to the medical team.*

12. THE ROLE OF PATIENT EDUCATION IN PRESERVING CARDIAC FUNCTION

Patient education, a cross-cutting component of the entire rehabilitation program, takes on a specific focus in the context of this manual: the patient must understand, in accessible language, that regular physical exercise, along with adherence to the prescribed treatment and control of risk factors, is an active intervention to protect their own "heart pump," not just a way to feel better in the short term.

- explaining, in simple terms, the concept of ventricular remodeling and the patient's active role in influencing it;
- the patient's recognition of the warning signs discussed earlier (rapid weight gain, worsening shortness of breath) and the immediate steps to take if they occur;
- the importance of self-monitoring body weight as a simple yet valuable tool for the early detection of fluid retention;
- maintaining motivation to continue exercising in Phase III, beyond the period of direct supervision.

Practical Note: *A simple yet effective message for the patient: "Every exercise session is a form of treatment for your heart, just like the medications you take"—a statement that can help increase the patient's awareness of the program's true therapeutic value.*

- **The Teach-Back Technique in Patient Education**

A simple and effective method for verifying that information has been correctly understood is the "teach-back" technique: after explaining a concept or a procedure (for example, warning signs that require contacting the medical team), the patient is asked to restate, in their own words, what they have retained. This technique allows for the rapid identification of misunderstandings without making the patient feel as though they are being "tested," and it is easy for a student clinician to apply during educational discussions.

- **Involving the Family in the Educational Process**

For elderly patients or those with limited cognitive function, involving a family member in educational discussions regarding warning signs and appropriate actions significantly increases the likelihood of early recognition of a potential deterioration in clinical condition at home, complementing the monitoring conducted during scheduled visits to the ward.

Table70 . Frequently Asked Questions from Patients and Response Guidelines

Frequently Asked Patient Questions	Suggested response
"Aren't I afraid that exercising will strain my heart even more?"	Explain, in simple terms, that controlled, supervised exercise trains the heart much like a muscle, unlike uncontrolled, sudden exertion
"Why don't I feel any difference, even though I've been exercising for 3 weeks?"	Explain that some benefits (peripheral muscle function) appear more quickly than others (cardiac remodeling), which may take several months

13. WORKSHEETS

Table 71 . Initial Assessment Worksheet

Section	Items to Fill Out
General Information	Age, sex, primary diagnosis, date of event/procedure
Ventricular function	Ejection fraction, if available, date of last echocardiographic evaluation
Functional capacity	Result of exercise testing or 6-minute walk test
Risk factors	Smoking, dyslipidemia, hypertension, diabetes, obesity
Current treatment	Therapeutic classes relevant to exercise response
Individual goals	Goals discussed and agreed upon with the patient

- **Exercise Session Monitoring Form**

This form, completed at each session, tracks heart rate, blood pressure, and the Borg scale score, measured before exercise, at peak exertion, and during the recovery period, along with any symptoms reported by the patient—a structure similar to that presented in the manual dedicated to complex cases, adapted here with an emphasis on comparing changes over time in tolerance to a reference workload, which is relevant for the indirect monitoring of cardiac output.

- **Student Practice Journal**

During the clinical rotation, it is recommended that each master's student maintain a clinical practice journal, in which they record, for each day of the rotation, the number of patients assisted, the procedures in which they actively participated, relevant clinical observations, and any questions or concerns to be discussed with the clinical coordinator—a useful tool for both self-assessment and the final evaluation of the internship.

- **Discharge Form from the Rehabilitation Program**

Upon completion of Phase II, it is recommended to complete a discharge summary from the supervised program, summarizing the evolution of functional performance parameters and, when available, the ejection fraction, the objectives achieved, and specific recommendations for Phase III—a document useful both to the patient and to the primary care physician or cardiologist who will take over long-term follow-up.

- **Communication with the Family Physician and the Attending Physician**

A concise medical letter, sent at the end of the structured program and containing the main findings and recommendations, ensures continuity of care and facilitates the patient's long-term monitoring outside the rehabilitation unit—a practice that the student is encouraged to actively observe during the clinical rotation, even though the final drafting remains the responsibility of the supervising physician.

14. CASE STUDIES

- **Case 1**

A 56-year-old patient, 6 weeks post-extensive anterior myocardial infarction, with an ejection fraction of 32% on a recent echocardiographic evaluation, currently receiving optimized treatment for heart failure. He is enrolled in Phase II of the rehabilitation program.

Requirements:

1. Explain, from a pathophysiological perspective, why this patient is at risk for progressive ventricular remodeling in the absence of appropriate intervention.
2. Propose a suggested structure for the exercise prescription for the first four weeks of Phase II.
3. List the parameters you will actively monitor at each session to detect any potential deterioration in left ventricular function early on.

- **Case 2**

A 68-year-old female patient with HFpEF, long-standing hypertension, and obesity, with an ejection fraction of 55%, but with reduced exercise tolerance (severely reduced peak VO_2 on cardiopulmonary testing) and dyspnea on moderate exertion.

Requirements:

4. Explain why, despite a normal ejection fraction, this patient has significantly reduced exercise capacity.
5. Discuss whether and how the goals of the rehabilitation program for this patient differ from those of the patient in the first case, who has HFrEF.
6. Identify the components of the program (exercise, weight control, blood pressure control) that are most relevant to this patient's profile.

Practical Note: *The two cases illustrate the fundamental difference in approach between HFrEF and HFpEF, discussed at length in Chapter 3: although both conditions represent forms of left ventricular dysfunction, their different pathophysiological mechanisms necessitate partially different therapeutic priorities and rehabilitation goals.*

- **Case 3**

A 61-year-old male with dilated cardiomyopathy of non-ischemic etiology, ejection fraction 28%, who has had a CRT-D (cardiac resynchronization defibrillator) implanted for 4 months, presenting for his first evaluation for inclusion in a cardiovascular rehabilitation program, NYHA functional class II.

Requirements:

7. Specify the additional, device-specific information you must obtain before prescribing an exercise regimen.
8. Propose a tentative plan for evaluating the response to resynchronization therapy, in conjunction with the rehabilitation program.
9. Discuss how you would adapt the intensity and progression of the exercise for this patient, compared to a patient with a similar ejection fraction but without a device.

Practical Note: *The third case introduces an additional element of complexity—the presence of a resynchronization device—and encourages the master's student to integrate, into a single line of reasoning, the principles discussed in Chapters 6 (prescription), 9 (monitoring), and 10 (special considerations for severe dysfunction and devices).*

- **GUIDELINES FOR SOLVING CASE STUDIES**

The guidelines below are general in nature and are intended for self-assessment or seminar discussion; they are not intended to replace individualized clinical reasoning, which depends on the complete data of each actual case.

- **Case 1 (post-infarction, EF 32%, phase II)**
    - risk of progressive remodeling: the infarcted area becomes non-contractile fibrous tissue, and the remaining myocardium compensates through dilation and hypertrophy,

a process that can become self-sustaining through neurohormonal activation if not counteracted therapeutically and through exercise;
- Guideline for the first 4 weeks: continuous aerobic training, light-to-moderate intensity (30–50% of RHR), 15–20-minute sessions, with a gradual increase in duration before increasing intensity;
- parameters to monitor: daily body weight, subjective tolerance to constant exertion (Borg scale), signs of congestion, heart rate, and blood pressure at each session.

- **Case 2 (HFpEF, obesity, severely reduced VO_2)**
  - Reduced exercise capacity with normal EF: the dominant mechanism is diastolic dysfunction (impaired relaxation and compliance), exacerbated by vascular stiffness associated with obesity and hypertension; it is not a problem of systolic contractility;
  - Differences in treatment goals compared to Case 1: for this patient, the focus is less on potential reverse remodeling of EF (which is already normal) and more on improving peripheral functional capacity and on aggressive management of weight and blood pressure;
  - Priority components: weight control (realistic goal of 5–10% of initial weight), strict blood pressure control, aerobic training adapted to reduced capacity, with short, frequent sessions.

- **Case 3 (dilated cardiomyopathy, CRT-D, EF 28%)**
  - Additional information required: the heart rate threshold at which the device intervenes (antitachycardia therapy/shock), the type of CRT programming (biventricular pacing rate), results of the most recent device check;
  - Assessment of response to CRT: echocardiographic reevaluation 3–6 months post-implantation, comparing EF and ventricular volumes with pre-implantation values, to classify the patient as a "responder" or "non-responder";
  - adjustment relative to a similar patient without a device: the maximum intensity should be maintained with a safety margin below the ICD's detection threshold, and progression may be slightly more aggressive if the patient proves to be a "responder" to resynchronization therapy, with documented improvement in EF.

15. THE ROLE OF NUTRITION AND CVR CONTROL IN PRESERVING LEFT VENTRICULAR FUNCTION

- **Blood Pressure Control and Chronic Afterload**

Uncontrolled hypertension is one of the main causes of chronic increases in left ventricular afterload, promoting the concentric remodeling discussed in Chapter 3 and, over time, diastolic dysfunction. Adequate blood pressure control, achieved through a combination of pharmacological treatment, sodium restriction, and regular physical exercise, is an intervention that directly impacts chronic afterload and, consequently, long-term ventricular function.

- **Body Weight and Lipid Profile Management**

Obesity and dyslipidemia contribute to ventricular dysfunction through multiple mechanisms—increased afterload, low-grade systemic inflammation, and accelerated coronary atherosclerosis—which is why control of these risk factors must be systematically integrated into the recovery program, rather than treated as a separate, optional component.

- **Sodium Intake in Patients with Ventricular Dysfunction**

In patients with heart failure, moderate restriction of sodium intake (approximately less than 5 g of salt per day) helps prevent fluid and salt retention and, indirectly, reduces the risk of decompensation, with a favorable impact on the number of exercise sessions missed due to clinical instability.

- **Nutritional Status in Patients with Advanced Ventricular Dysfunction**

At the opposite end of the spectrum from obesity, cardiac cachexia—discussed at length in the manual dedicated to complex cases—is a complication of advanced heart failure with a negative impact on prognosis; for this reason, active nutritional assessment must be part of routine monitoring, alongside cardiac parameters themselves.

Practical note: *A patient with ventricular dysfunction who is progressively losing weight, without a clear explanation related to intentional calorie restriction, should be actively evaluated for cardiac cachexia, not commended for weight loss.*

Table 72 . Summary of non-pharmacological interventions aimed at improving left ventricular function

Intervention	Primary Mechanism of Protection of LV Function
Regular aerobic exercise	Partial reverse remodeling, peripheral mechanisms, reduction in sympathetic tone
Tension control	Reduction of chronic afterload
Weight control	Reduction of systemic inflammation and obesity-associated post-load
Moderate sodium restriction	Prevention of fluid and salt retention and episodes of decompensation
Nutritional support for cachectic patients	Prevention/limitation of muscle mass loss with functional impact
Smoking cessation	Improvement of endothelial function, reduction of atherosclerosis progression

Summary: *Blood pressure control, management of body weight and lipid profile, moderate sodium restriction, and active monitoring of nutritional status are interventions that complement physical exercise and have a direct impact on chronic left ventricular dysfunction, the risk of decompensation, and, ultimately, long-term left ventricular performance.*

16. EMERGING TECHNOLOGIES IN MONITORING LEFT VENTRICULAR FUNCTION

- **Telemonitoring of Hemodynamic Parameters**

Dedicated implantable devices capable of remotely estimating intracardiac or pulmonary pressures have been developed in recent years for the proactive monitoring of patients with advanced heart failure, allowing for therapeutic adjustments before the onset of overt symptoms of decompensation. Although the use of these technologies does not fall directly within the scope of the recovery unit, awareness of their existence is useful for understanding the care context of some of the complex patients encountered in clinical practice.

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- **Mobile Apps and Wearable Devices**

Wearables, capable of recording heart rate, daily physical activity, and—in some models—simplified heart rhythm, provide an additional source of data for monitoring patients in Phase III at home, complementing periodic visits to the unit. This data should be interpreted with caution, taking into account the accuracy limitations of consumer devices compared to certified medical equipment.

- **Artificial Intelligence in Echocardiographic Interpretation**

Artificial intelligence-based algorithms, increasingly integrated into modern echocardiography equipment, assist in the automatic measurement of ejection fraction and other structural parameters, with the aim of reducing the inter-observer variability discussed in Chapter 2. These tools currently serve as an aid to clinical interpretation, not a substitute for medical judgment.

- **Challenges Related to the Adoption of These Technologies in Current Practice**

The widespread adoption of these emerging technologies faces significant practical obstacles: initial implementation costs, the need for rigorous validation in diverse populations, the integration of the generated data into the department's existing workflow, and, last but not least, the need for ongoing education of medical staff and medical students in the proper use and interpretation of these new tools.

Summary: *Hemodynamic telemonitoring, wearable devices, and artificial intelligence-based tools represent emerging technological trends that complement—rather than replace—the traditional clinical assessment of left ventricular performance discussed in this manual.*

Appendix 1. Expanded Initial Assessment Form Focused on Left Ventricular Performance

- Initial evaluation = the baseline for all subsequent re-evaluations of the patient.

Table73 . Comprehensive Initial Assessment Checklist Focused on Left Ventricular Function

Section	Items to be completed
Diagnosis and context	Primary diagnosis, date of event/procedure, type of procedure (if applicable)
Echocardiographic parameters	Ejection fraction, global longitudinal strain (if available), ventricular dimensions and volumes
Biomarkers and metabolic profile	NT-proBNP/BNP, lipid profile, HbA1c (if applicable), renal function
Formal exercise testing	Test type (standard/CPET/stress echocardiography), METs or peak VO_2, ventilatory threshold, presence of ischemia/arrhythmias
Submaximal field tests	Distance covered in the 6-minute walk test, walking speed over 10 meters (if relevant)
Strength and physical performance tests	Grip strength (dynamometry), sit-to-stand score, SPPB score, TUG time
Subjective perception of exertion	Borg scale score for the reference task used in the initial testing
Quality of life and functional status	MLHFQ or KCCQ score (as applicable), DASI score, if used
Cardiac devices	Device type, date of implantation, relevant programming parameters
Current treatment	Therapeutic classes, with an emphasis on those discussed in Chapter 11
Risk factors and nutritional status	Smoking, dyslipidemia, hypertension, diabetes, body weight, and recent changes
Planned home monitoring	Availability of a wearable device, frequency of self-monitoring of weight
Individual goals	Functional goals discussed and agreed upon with the patient

Practical note: *Not all lines on this form need to be completed for every patient—the choice of tests actually used in the initial assessment follows selection principles adapted to the resources available in the department.*

Appendix 2. Guideline for Emergency Procedures During a Drill

The protocol below is intended as a guideline and must be adapted to the resources and organization of each individual department; it must be known to all staff involved in conducting drill sessions.

1. Immediately stop the patient's physical activity at the first sign of a severe emergency;
2. Place the patient in a comfortable position, usually semi-sitting, and quickly assess their level of consciousness and vital signs;
3. Immediately request assistance from the on-call physician or nurse in the unit;
4. Prepare emergency equipment (automated external defibrillator, emergency kit) for immediate use, if the situation warrants it;
5. Initiate cardiopulmonary resuscitation (CPR), if necessary, in accordance with standard protocols, performed by trained personnel;
6. Fully document the event in the patient's chart immediately after the situation has been stabilized, explicitly stating the test or activity in progress at the time the warning signs appeared (routine exercise session, formal stress test, 6-minute walk test, or other monitoring tool).

Practical Note: *The student intern never leads an emergency response alone, but must be familiar with this protocol in order to effectively support the team (for example, by quickly retrieving emergency equipment or alerting other team members), without interfering with the clinical decisions of qualified personnel.*

Practical note: *When the event occurs during a formal monitoring test (standard exercise test, CPET, or stress echocardiography), the specific criteria for terminating that test—discussed in the chapter on exercise testing—apply in addition, and emergency equipment must already be prepared in the laboratory, in accordance with best practice, rather than brought in later.*

Appendix 3. Quick Guide for the Preliminary Interpretation of LV Performance Parameters

Table 74 . Quick Guide to Interpreting Left Ventricular Performance Parameters

Finding	Preliminary Interpretation	Suggested Management
EF stable compared to the previous evaluation	No deterioration in systolic function	Continue the program as planned
Decreased EF compared to the previous assessment	Possible deterioration in systolic function or measurement error	Clinical correlation, possible repeat measurement, discussion with the coordinating physician
Significant increase in NT-proBNP	Possible increase in filling pressures	Clinical evaluation for signs of congestion; possible temporary reduction in severity
Increased peak VO2 on retest	Favorable response to the exercise program	Possible progression in intensity, according to protocol
Distance covered in the 6-minute walk test increased by more than 25–30 m	Clinically relevant improvement in functional capacity (above the MCID threshold)	Confirmation of the program's benefit; possible progression in intensity
Decreased distance on the 6-minute walk test	Possible functional deterioration or intercurrent extracardiac factor	Clinical reevaluation, verification of standardized testing conditions
Decreased Borg score at the same reference workload	Improved subjective exercise tolerance	Indirect favorable sign, corroborated by other parameters
Increasing Borg score at the same reference workload	Possible deterioration in functional capacity or associated psychological factor	Further clinical evaluation, without ignoring the psychosocial component
Improving KCCQ/MLHFQ score	The patient's perception of the disease's impact has improved	A positive sign, useful for encouraging the patient
SPPB score or TUG time showing an unfavorable trend	Increasing functional and fall risk, possible frailty	Multidisciplinary reassessment, with an emphasis on strength and balance exercises
Reduced subjective tolerance, with unchanged objective parameters	Possible non-cardiac cause (anemia, muscle deconditioning, psychological factors)	Complementary multidisciplinary evaluation

Practical note: *This guide is strictly for informational and educational purposes; any interpretation of changes in LV performance parameters or associated functional tests must be validated by the department's coordinating physician, within the context of the patient's complete clinical picture.*

Appendix 4. Sample of a Completed Initial Evaluation Form

- Instructions for completing the expanded form presented in Appendix 1, including the results of functional tests

Table75 . Sample of a completed initial assessment form

Section	Example of how to complete
Diagnosis and context	Extensive anterior myocardial infarction, 6 weeks ago; no surgery, primary angioplasty
Echocardiographic parameters	EF 32% (Simpson biplanar), no GLS available at this evaluation
Biomarkers and metabolic profile	NT-proBNP = 850 pg/mL (collected 2 weeks prior); lipid profile currently being optimized with statin therapy
Formal exercise testing	Standard exercise test, modified Bruce protocol: 5.2 METs, no ischemia or significant arrhythmias
Submaximal Field Tests	6-minute walk test: 380 meters (reference value for subsequent reassessments)
Strength and physical performance tests	Grip strength: 28 kg (dominant hand); sit-to-stand: 11 repetitions in 30 seconds
Subjective Perception of Exertion	Borg score of 13 (“somewhat strenuous”) at the end of the 6-minute walk test
Quality of life and functional status	Baseline MLHFQ score: 42/105 (moderate impact, predominantly affected physical domain)
Cardiac devices	No implanted device
Current treatment	ACE inhibitor, beta-blocker, mineralocorticoid receptor antagonist, statin
Risk factors and nutritional status	Former smoker (quit after the event), BMI 27, no other significant comorbidities
Planned home monitoring	Wearable device available (smartphone with step-counting app); personal scale at home
Individual goals	Return to work (predominantly sedentary job) in approximately 6 weeks

Practical note: *This example is for educational purposes only; the numerical data are fabricated to illustrate how to complete the form and should not be used as clinical reference values. The 6-minute walk test and MLHFQ scores noted here constitute the “baseline” against which subsequent reassessments of this patient should be interpreted, in accordance with the principles in Appendix 3.*

ABBREVIATIONS

Table 76 . Glossary of Abbreviations – Chapter III

Abbreviation	Meaning
6MWT	Six-minute walk test
BNP / NT-proBNP	B-type natriuretic peptide / N-terminal pro-BNP fragment
CPET	Cardiopulmonary exercise testing with direct measurement of gas exchange
CRT	Cardiac resynchronization therapy
CRT-D	Cardiac resynchronization therapy with defibrillator function
DASI	Duke Activity Status Index, a questionnaire for indirect assessment of functional capacity
EF	Ejection Fraction
EQ-5D	General quality-of-life questionnaire with 5 dimensions
ET	Standard exercise test (electrocardiographic), on a cycle ergometer or treadmill
GLS	Global Longitudinal Strain
HFpEF	Heart failure with preserved ejection fraction (≥ 50%)
HFrEF	Heart failure with reduced ejection fraction (< 50%)
ICD	Implantable cardiac defibrillator
ISWT	Incremental Shuttle Walk Test
KCCQ	Kansas City Cardiomyopathy Questionnaire, a questionnaire assessing functional status and quality of life
LV	Left ventricle
LVAD	Left Ventricular Assist Device
MCID	Minimal clinically important difference
MET	Metabolic equivalent, a unit of measurement for the intensity of physical exertion
MLHFQ	Minnesota Living with Heart Failure Questionnaire, a quality-of-life questionnaire specific to heart failure
O_2 pulse	A surrogate for stroke volume during exercise, determined by CPET
Peak VO_2	Maximum oxygen consumption achieved during a cardiopulmonary exercise test
RAAS	Renin-angiotensin-aldosterone system
RER	Respiratory exchange ratio (RER), indicating the degree of maximal exertion achieved
RPE / Borg Scale	Rating of Perceived Exertion (6–20 or CR10)
SF-36	Short Form 36, a general questionnaire assessing health-related quality of life
SPPB	Short Physical Performance Battery, a composite battery for assessing physical performance
TUG	Timed Up and Go, a test of functional mobility and fall risk
VE/VCO_2 (slope)	Indicator of ventilatory efficiency, determined by CPET
VT (ventilatory threshold)	The intensity of exercise at which metabolism becomes predominantly anaerobic

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CHAPTER IV. RECOVERY OF PATIENTS WITH VASCULAR DISEASE IN THE ERA OF REVASCULARIZATION

Laura Crăciun

1. INTRODUCTION

- **Atherosclerosis as a systemic disease—the concept of the "vascular disease patient"**

Atherosclerosis is a systemic pathological process that simultaneously affects—albeit at different rates and with varying clinical manifestations—several arterial territories: coronary, cerebral, peripheral, renal, and aortic. The term "vascular disease patient" refers, for the purposes of this manual, any patient with documented atherosclerotic disease in one or more of these regions, regardless of which region gave rise to the initial clinical presentation, thereby highlighting the increased, cross-regional risk of events in the other regions, even in the absence of local symptoms.

- **Epidemiological Highlights**

Atherosclerotic cardiovascular diseases remain the leading cause of mortality worldwide, and stroke, in turn, is one of the leading causes of long-term disability in adults. Peripheral arterial disease, although often underdiagnosed due to its less dramatic clinical presentation, affects a significant proportion of the elderly population and is associated with a risk of cardiovascular mortality comparable to that of symptomatic coronary artery disease.

- **The Era of Revascularization—How Has the Profile of Patients Enrolled in Cardiovascular Rehabilitation Programs Changed?**

Advances in revascularization techniques—percutaneous coronary intervention, thrombolysis and mechanical thrombectomy for stroke, and peripheral angioplasty and bypass surgery—have radically altered the immediate prognosis of acute atherosclerotic events, significantly reducing mortality and, in many patients, the severity of functional sequelae. This evolution has, in turn, altered the typical profile of the patient referred for rehabilitation: fewer patients with massive, irreversible sequelae, but more patients with residual ischemia, at risk of restenosis or reocclusion, and with active systemic atherosclerotic disease requiring aggressive management, regardless of immediate procedural success.

- **Why should chronic coronary syndrome (CCS), stroke, and peripheral arterial disease (PAD) be viewed as a unified entity rather than as separate conditions?**

Rehabilitation programs have historically developed relatively separately for cardiology and neurology, and peripheral arterial disease has often remained an area less well-covered by either specialty. However, this institutional fragmentation does not reflect the pathophysiological reality: a patient with coronary artery disease has a significantly increased risk of concurrently having asymptomatic carotid or peripheral artery disease, and the risk factors and secondary prevention interventions are, to a large extent, common to all three conditions. This manual proposes an integrated approach that explicitly acknowledges these overlaps.

- **Objectives**
  - to explain the common pathophysiological mechanisms of atherosclerotic disease in the three main vascular territories;
  - to recognize the clinical and functional characteristics of patients following coronary, cerebral, and peripheral revascularization;
  - to perform an initial assessment that explicitly covers the risk of multivascular involvement, not just the symptomatic territory;
  - tailoring exercise prescriptions to the specific characteristics of each territory and to the possible coexistence of multiple conditions;

- recognizing the warning signs specific to each vascular territory and taking appropriate action;
- integrating the management of common risk factors as a central—not merely ancillary—component of the rehabilitation program.

Practical Note: *This chapter deliberately groups coronary artery disease (CAD), stroke, and peripheral arterial disease (PAD) under the common label of "atherosclerotic disease," not to downplay the specific characteristics of each vascular territory—which are discussed in detail in the following chapters—but to highlight the common pathophysiological and therapeutic thread that links them.*

- **Structure**

✓ Pathophysiological Foundations: Atherosclerosis, the Three Vascular Territories, Multivascular Disease

✓ Assessment, Regional Recovery Characteristics, and Integrated Exercise Prescription

✓ Common risk factors, monitoring, and psychological aspects

✓ Practical organization and working documents

✓ Applied case studies and conclusions

2. PATHOPHYSIOLOGY OF ATHEROSCLEROSIS AND SYSTEMIC VASCULAR DISEASE

- **The Mechanism of Atherogenesis and Atheromatous Plaque**

Atherosclerosis begins with a dysfunction of the vascular endothelium, which becomes permeable to LDL-cholesterol particles that are retained in the arterial wall and undergo oxidative modification. This process triggers a local inflammatory response, with the recruitment of monocytes that transform into macrophages and, subsequently, into lipid-laden foam cells, forming the lipid core of the atherosclerotic plaque. The proliferation of smooth muscle cells and the deposition of extracellular matrix subsequently form the fibrous cap that covers this core.

- **From a stable plaque to an acute event—rupture and thrombosis**

A stable atherosclerotic plaque with a thick, stable fibrous cap can remain clinically silent for a long time, even if it causes significant stenosis. Acute events such as myocardial infarction, some ischemic strokes, and acute limb ischemia are largely caused by the rupture or erosion of a vulnerable plaque with a thin cap, followed by the formation of a thrombus that can suddenly occlude the arterial lumen or embolize distally. This pathophysiological understanding explains why the severity of angiographic stenosis, although important, is not the sole determinant of the risk of an acute event.

- **The concept of "multivessel disease"—simultaneous involvement of multiple arterial territories**

Multivessel disease refers to the documented presence of significant atherosclerosis in at least two distinct arterial territories (e.g., coronary and peripheral, or coronary and carotid). Epidemiological studies consistently show that patients with polyvascular disease have a significantly poorer prognosis than those with involvement limited to a single territory, even after successful revascularization of the symptomatic territory.

Table77 . Risk factors common to all three territories

Risk factor	Common mechanism
Dyslipidemia	Direct substrate for lipid deposition in the arterial wall, across all territories
Hypertension	Mechanical stress on the endothelium, accelerating arterial stiffening
Smoking	Endothelial dysfunction, oxidative stress, systemic procoagulant effect
Diabetes mellitus	Glycation of vascular proteins, accelerated endothelial dysfunction
Obesity (especially abdominal)	Low-grade systemic inflammation, insulin resistance, indirect worsening of dyslipidemia and hypertension
Sedentary lifestyle	Endothelial dysfunction and arterial stiffness exacerbated by the absence of regular blood flow stimulation
Age and male gender	Non-modifiable factors, with longer cumulative exposure to the other factors

- **Summary:** *Atherosclerosis is a unified systemic process, and its clinical manifestation in a specific territory (coronary, cerebral, or peripheral) depends more on the location of vulnerable plaques than on a fundamentally different disease; common risk factors and the concept of polyvascular disease justify an integrated approach to secondary prevention, regardless of the site that gave rise to the initial event.*

- **Systemic Inflammation**

Beyond the classic risk factors, a significant portion of the residual risk of atherosclerotic events is attributed to low-grade systemic inflammation, as evidenced by markers such as high-sensitivity

C-reactive protein. This observation has led to the development of targeted anti-inflammatory therapies, complementary to conventional lipid-lowering therapy, and explains why strict control of LDL cholesterol, while essential, does not completely eliminate residual risk in some patients.

- **Vascular Remodeling and Arterial Stiffening**

In addition to the formation of focal plaques, atherosclerosis is associated with a diffuse process of arterial wall stiffening, which increases cardiac afterload and contributes to isolated systolic hypertension, which is common in the elderly. This diffuse phenomenon explains why blood pressure control remains an essential intervention in patients with vascular disease, regardless of the specific treatment of focal lesions.

Practical note: *The distinction between focal lesions (atheromatous plaques, responsible for acute events) and the diffuse process (arterial stiffening, responsible for the chronic increase in afterload) is useful for understanding that successful focal revascularization does not address the diffuse component of the disease.*

3. CHRONIC CORONARY SYNDROME (CCS) IN THE ERA OF REVASCULARIZATION

- **From Stable Angina to Revascularized Acute Coronary Syndrome**

Atherosclerotic coronary artery disease manifests clinically along a continuous spectrum, the extremes of which are chronic coronary syndrome (CCS)—which includes stable angina and silent ischemia, relatively stable forms of the disease—and acute coronary syndrome (ACS), a term that encompasses unstable angina and myocardial infarction, with or without ST-segment elevation (STEMI and NSTEMI, respectively), which are manifestations of the acute destabilization of an atherosclerotic plaque. A patient can move along this spectrum in either direction: from CCS to an episode of ACS, through the rupture or erosion of a vulnerable plaque, or conversely, from an ACS treated by percutaneous or surgical revascularization, back to a chronic, stable form of the disease.
Chronic ischemic heart disease thus encompasses both the patient with "de novo" CHD, who has reached this stage directly without a preceding acute event, and, increasingly frequently in current practice, patients who have suffered an ACS episode (unstable angina or STEMI/NSTEMI myocardial infarction), treated with revascularization, and who subsequently remain carriers of chronic coronary artery disease, even if the lesion "responsible" for the acute event was successfully treated.

Table 78 . Coronary Revascularization—PCI versus CABG: Practical Implications for Cardiovascular Rehabilitation

Type of revascularization	Characteristics	Implications for recovery
Percutaneous coronary intervention (PCI)	Minimally invasive vascular approach, rapid physical recovery	Early mobilization possible; caution required at the vascular puncture site
Coronary artery bypass grafting (CABG)	Surgical procedure, with or without sternotomy	Sternal precautions, as discussed in textbooks on cardiac surgery; longer postoperative recovery

- **Residual ischemia and diffuse coronary artery disease in revascularized patients**

Revascularization of a "culprit" lesion does not, in many patients, eliminate the underlying diffuse coronary artery disease present in other arterial segments. These patients may exhibit residual ischemia, detectable by exercise testing, which must be explicitly taken into account when establishing the safety threshold for exercise intensity—it should not be assumed to be absent simply because the initial lesion was successfully treated.

Practical note: *"Revascularized" does not mean "cured": a patient who has undergone PCI or CABG remains, by definition, a patient with active atherosclerotic coronary artery disease, requiring aggressive control of risk factors, just like a patient who has not undergone interventional treatment.*

- **Silent Ischemia**

Some patients with coronary artery disease, particularly those with concomitant diabetes mellitus, may experience episodes of myocardial ischemia without the typical symptoms of chest pain (silent ischemia), detectable only through electrocardiographic changes or imaging tests. This situation requires extra vigilance during the exercise program, as the patient will not spontaneously report warning symptoms, and objective monitoring (electrocardiogram, hemodynamic parameters) becomes increasingly important.

Table 79 . Guidelines for the reevaluation of patients with revascularized CAD

Time	Recommended Assessment
Upon enrollment in the program	Exercise testing, echocardiography, lipid profile
At the end of Phase II	Repeat exercise testing to assess progress and adjust treatment
Annually or upon the onset of new symptoms	Comprehensive cardiological reevaluation, with stress testing or imaging, as indicated

Summary: *Chronic coronary syndrome, even after technically successful revascularization, remains an active disease with a risk of residual ischemia—sometimes asymptomatic—which is why objective monitoring and periodic reevaluation remain essential throughout the recovery program.*

4. PERIPHERAL ARTERIAL DISEASE (PAD)

- **The Fontaine/Rutherford Classification and the Severity of Ischemia**

In European clinical practice, the severity of PAD is described using the Fontaine classification, while in the English-language literature, the Rutherford classification is used, which is particularly useful for comparing results across clinical studies. The two systems do not overlap perfectly, but the indicative correspondence between them is useful for a consistent interpretation of the information, regardless of the source of the patient's medical records.

Table 86.. The Fontaine/Rutherford Classification of Peripheral Arterial Disease

Fontaine Stage	**Clinical Description**	
I	Asymptomatic, low ankle-brachial index	
II	Intermittent claudication (Stage IIa—at distances over 200 m; Stage IIb—at distances under 200 m)	
III	Ischemic rest pain	
IV	Ulcers or gangrene	
Rutherford grade/category	**Clinical Description**	**Approximate Fontaine correspondence**
0 / 0	Asymptomatic	I
I / 1	Mild claudication	IIa
I / 2	Moderate claudication	IIa–IIb
I / 3	Severe claudication	IIb
II / 4	Ischemic rest pain	III
III / 5	Minor tissue loss (limited ulceration)	IV
III / 6	Major tissue loss (extensive gangrene)	IV

- **Practical note:** *The correspondence between the two classifications is indicative, not strictly equivalent; when the patient's medical record uses the Rutherford classification, it should be used as is when communicating with the vascular team, rather than automatically converted to the Fontaine stage, to avoid ambiguity in the transmission of clinical information.*

- **Peripheral revascularization—angioplasty, stenting, surgical bypass**

Similar to the coronary territory, peripheral revascularization can be performed endovascularly (angioplasty with or without stenting) or surgically (bypass), with the choice depending on the location and complexity of the lesions. As with CAD, revascularization treats the lesion responsible for the symptoms but does not eliminate the underlying systemic atherosclerotic disease.

- **Supervised walking training versus revascularization—comparative evidence**

The available evidence shows that structured supervised walking training offers functional benefits comparable to—and in some patients even superior to—those achieved through revascularization alone, especially in patients at Fontaine stages IIa–IIb, which is why current guidelines recommend supervised walking training as the first-line therapy for this group, with revascularization reserved for cases with an inadequate response or more severe ischemia.

Practical Note: *In patients with PAD, walking exercise and revascularization should not be viewed as competing alternatives, but rather as complementary interventions that can be combined to achieve a better functional outcome than either one alone.*

- **Peripheral Artery Disease as a Marker of Systemic Cardiovascular Risk**

PAD represents, perhaps more strikingly than either of the other two conditions discussed in this manual, a marker of systemic atherosclerosis: a patient with intermittent claudication has a significantly increased e risk of coronary and cerebrovascular events, which is often a more relevant prognostic factor than the local progression of peripheral disease; for this reason, a diagnosis of PAD should automatically trigger a comprehensive cardiovascular evaluation, not just local symptomatic treatment.

- **Ankle-Brachial Index – Technique**

The ankle-brachial index (ABI) is the ratio of systolic blood pressure at the ankle to that at the arm. It is typically measured using a portable vascular Doppler.

Materials Needed

- Portable vascular Doppler with a 5–10 MHz probe
- Blood pressure monitor with appropriately sized cuffs (the cuff width must be at least 40% of the limb's circumference).
- Ultrasound gel

Patient preparation

- The patient lies on his or her back (supine position), at rest, for 5–10 minutes before the measurement, with the head and heels supported.
- The patient should not smoke for at least 2 hours beforehand.
- Tight clothing on the arms and legs is removed, and dressings and ulcers are protected.

Measurement Technique

1. On the arm: The cuff is placed on the arm, and the Doppler probe is positioned on the brachial artery at the elbow crease. The cuff is inflated to approximately 20 mmHg above the point at which the signal disappears. It is deflated slowly, at a rate of approximately 2 mmHg per second. The pressure at which the signal reappears is the systolic pressure.
2. At the ankle: Place the cuff on the lower leg, with the lower edge approximately 2 cm above the malleoli. Measure the systolic pressure on:
    - the posterior tibial artery, behind the medial malleolus
    - the dorsal artery of the foot (pedal artery), on the dorsal aspect of the foot
3. Hold the probe at a 45–60° angle to the artery, without pressing on the vessel.
4. Recommended order (AHA—American Heart Association): right arm, then right posterior tibial, right pedial, left posterior tibial, left pedial, and left arm. Finally, repeat the measurement on the first arm. If it differs by more than 10 mmHg from the first value, the first measurement is disregarded.

Calculation—calculate separately for each leg:

ABI = highest systolic pressure at the ankle (posterior tibial or pedial) ÷ highest systolic pressure at the arm (right or left)

Example: right ankle 110 mmHg, and arms 140 and 130 mmHg. Right ABI = 110 ÷ 140 = **0.79**.

Table 87. Ankle-Brachial Index – Interpretation

Ankle-brachial index value	Interpretation
> 1.40	Non-compressible vessels (common in people with diabetes); requires further evaluation
1.00–1.40	Normal
0.91–0.99	Borderline
0.41–0.90	Mild to moderate BAP
≤ 0.40	Severe BAP

5. ATHEROSCLEROTIC STROKE

- **Atherothrombotic ischemic stroke—etiological characteristics**

Atherothrombotic ischemic stroke results from the occlusion or distal embolization of an atherosclerotic plaque typically located at the carotid bifurcation or in the large intracranial arteries; this mechanism is distinct from cardioembolic stroke (frequently associated with atrial fibrillation) or microvascular lacunar infarcts, an etiological distinction relevant to the secondary prevention strategy.

- **Cerebral revascularization—thrombolysis, mechanical thrombectomy**

In the acute phase, intravenous thrombolysis and mechanical thrombectomy (direct removal of the thrombus via a catheter in patients with large-vessel occlusion) have significantly reduced the severity of neurological sequelae in patients treated promptly, which means that an increasing percentage of post-stroke patients in the recovery phase have moderate, rather than severe, functional deficits; however, like cardiac patients, they require rigorous control of atherosclerotic risk factors to prevent recurrence.

- **Carotid endarterectomy and carotid stenting—secondary prevention**

In patients with significant, symptomatic carotid stenosis, surgical endarterectomy or, in selected cases, carotid stenting significantly reduces the risk of recurrent stroke. Familiarity with these procedures is important for the rehabilitation team, as the postoperative/post-procedural period requires specific precautions (avoiding sudden neck movements in the first few weeks after endarterectomy, careful blood pressure monitoring).

- **Distinct Features of Neurological Rehabilitation Versus Traditional Cardiovascular Rehabilitation**

Post-stroke recovery is typically led primarily by neurological rehabilitation teams, focusing on motor, speech, and cognitive deficits. The cardiovascular component of recovery—risk factor control and aerobic training for secondary prevention—is often underrepresented in these programs, although evidence supports its clear benefits; for this reason, integrating the two perspectives—neurological and cardiovascular—is an explicit objective of this manual.

Summary: *Atherothrombotic stroke is the cerebral manifestation of the same atherosclerotic process discussed in the context of coronary artery disease (CAD), and the post-stroke patient, like the post-coronary event patient, remains a patient with active atherosclerotic disease who benefits from a structured cardiovascular rehabilitation component that is integrated with—not subordinate to—classical neurological rehabilitation.*

Table80 . Modified Rankin Scale—a guideline for assessing disability

Rankin Score	Description
0	No symptoms
1	No significant disability, despite symptoms
2	Mild disability; unable to perform all previous activities, but independent
3	Moderate disability; requires assistance, but can walk independently
4	Moderate-severe disability; cannot walk without assistance
5	Severe disability; continuous care required

Patients with a Rankin score of 1–3 represent the typical target population for integration into a structured cardiovascular rehabilitation program, alongside standard neuromotor rehabilitation, as they are functional enough to actively participate in exercise but have specific adaptation needs.

- **Atrial Fibrillation and Stroke—An Important Etiological Distinction**

It is essential for the master's student to distinguish between atherothrombotic stroke—the subject of this chapter—and cardioembolic stroke, which is frequently associated with atrial fibrillation, since secondary prevention strategies differ significantly: aggressive control of classic atherosclerotic risk factors in the former, and oral anticoagulation in the latter. In fact, many patients exhibit both mechanisms simultaneously, which requires a dual therapeutic approach.

6. THE PATIENT WITH MULTIVASCULAR ATHEROSCLEROTIC DISEASE

- **Prevalence and Prognosis of the Multivascular Patient**

A significant proportion of patients with documented coronary artery disease present, upon active evaluation, with asymptomatic atherosclerotic involvement in the carotid or peripheral arteries, and the presence of this additional involvement is associated with an increased risk of major cardiovascular events and mortality compared with involvement limited to a single site. The 2024 ESC Guidelines on Peripheral and Aortic Arterial Disease estimate that polyvascular disease affects approximately one in four to one in six patients with atherosclerosis; this population has a risk of cardiovascular events nearly double that of patients with disease limited to a single arterial territory.

Table 81 . Screening for asymptomatic involvement of other territories

Screening territory	**Simple, accessible method**
Carotid	Auscultation for carotid murmur; Doppler ultrasound if suspected or high risk
Peripheral (lower extremities)	Palpation of peripheral pulses; ankle-brachial index
Aortic (aneurysm)	Abdominal palpation; ultrasound in high-risk patients (elderly smokers)

- **Therapeutic priorities in patients with CAD + PAD or CAD + stroke**

In patients with documented involvement in multiple vascular territories, risk factor control should be intensified, with stricter therapeutic goals (e.g., lower LDL-cholesterol targets), and the rehabilitation program must explicitly incorporate precautions specific to each affected territory, not just those of the territory that led to the initial presentation.

- **The Impact of Polyvascular Disease on Therapeutic Decision-Making**

Beyond intensifying medical treatment, the presence of polyvascular disease can also influence procedural decisions—for example, a patient with significant carotid stenosis, discovered incidentally prior to a coronary bypass procedure, may require careful sequencing of the two revascularization procedures, a decision that goes beyond the scope of the recovery team but which the team must be aware of in order to understand the patient's full clinical context.

Summary: *Active screening for asymptomatic polyvascular disease, using simple and accessible methods, should be part of the routine evaluation of any patient enrolled in a cardiovascular rehabilitation program following a coronary, cerebrovascular, or peripheral event, given the documented prognostic impact of polyvascular disease on medical management and, at times, on procedural decisions.*

7. INITIAL EVALUATION OF PATIENTS WITH EXTENSIVE ATHEROSCLEROTIC DISEASE

- **Medical history and clinical examination focused on the three territories**

The medical history should actively explore symptoms in all three domains—chest pain or angina-like symptoms, transient neurological symptoms or residual deficits, and claudication or pain in the lower extremities—not just the domain that prompted the referral to rehabilitation, and the clinical examination must systematically include palpation of peripheral pulses and auscultation for vascular murmurs.

- **Minimum Laboratory and Diagnostic Tests**

In patients with extensive atherosclerotic disease, the medical history and clinical examination must be supplemented with a minimum set of laboratory and diagnostic tests, which not only confirm the diagnosis and severity of the condition but also directly guide the therapeutic targets discussed in detail in Chapter 12 and the risk stratification presented at the end of this chapter.

Table 82 . Minimum laboratory and diagnostic workup for patients with extensive atherosclerotic disease

Category	Recommended Minimum Tests	Primary Relevance
Laboratory Tests	Complete lipid profile (total cholesterol, LDL, HDL, triglycerides), fasting blood glucose and/or HbA1c, renal function (creatinine, estimated glomerular filtration rate), complete blood count	Establishment of lipid and glycemic targets, exclusion of anemia as a factor limiting exercise capacity, assessment of renal function relevant to overall cardiovascular risk
Resting electrocardiogram	12-lead ECG	Screening for arrhythmias, signs of old necrosis/ischemia, and conduction disturbances
Transthoracic echocardiography	Assessment of ejection fraction, segmental kinetics, and associated valvular diseases	Minimum required laboratory tests for patients with documented coronary artery disease, with direct impact on risk stratification
Vascular Doppler ultrasound (as indicated)	Carotid Doppler in patients at risk for polyvascular disease (Chapter 6); peripheral arterial Doppler in patients with an altered ankle-brachial index	Confirms or rules out additional involvement in asymptomatic territories, which is essential for polyvascular screening

Practical note: *This assessment represents a minimum guideline, not an exhaustive list; additional investigations (e.g., cerebral imaging, coronary or peripheral angiography) may be necessary, as indicated by the attending physician, depending on each patient's specific clinical context.*

- **Explicit documentation of the status of each territory during the initial evaluation**

It is recommended that the initial assessment form for any patient with atherosclerotic disease include a separate section for each of the three territories, explicitly filled out either with the relevant data or with the notation "no assessment available" or "no documented involvement" — rather than left blank, which could later be interpreted either as "not assessed" or as "not affected," with different implications for clinical decision-making.

Table 83 . Territory-specific functional assessment

Region	Functional assessment tool
Coronary	Standard exercise or cardiopulmonary testing
Cerebral	Standardized neurological scales (e.g., NIHSS for severity, modified Rankin scale for disability)
Peripheral	Ankle-brachial index, 6-minute walk test, claudication distance

- **The role of territory-specific quality-of-life questionnaires**

In addition to objective functional measures, region-specific quality-of-life questionnaires—for example, questionnaires focused on claudication for PAD or post-stroke quality-of-life scales—provide a complementary, patient-centered perspective that is useful for tailoring program goals and monitoring subjective progress alongside objective functional parameters.

- **Overall risk stratification prior to enrollment in the rehabilitation program**

Regardless of the clinical indication for referral, the inclusion of a patient with extensive atherosclerotic disease in a rehabilitation/physical training program must always be preceded by explicit risk stratification, which integrates the results of the medical history, clinical examination, laboratory and paraclinical tests, and functional assessment across the three domains discussed in the previous sections of this chapter. This risk stratification is not an administrative step, but rather a clinical decision that determines both the safety of initiating the program and the level of supervision required.

- **Risk Stratification in Patients Who Have Undergone Multiple Revascularization Procedures**

In patients who have undergone revascularization in multiple areas, risk stratification must incorporate factors specific to each procedure (type of revascularization, complications, time elapsed since the procedure) and identify the area with the highest residual vulnerability, which will guide the prioritization of precautions in the exercise program.

Practical Note: *An initial assessment focused exclusively on the territory that prompted the referral (e.g., solely cardiological, in a patient referred post-myocardial infarction) risks overlooking significant carotid or peripheral disease that is already documented in the medical record but not explicitly considered by the rehabilitation team.*

Table 84 . Integrated risk stratification in the multivascular patient

Risk Category	Guidance criteria for classification (integrated assessment across the three domains)	Implications for inclusion in the program
Low-to-moderate risk	A single affected territory, stable, without residual ischemia, without significant functional deficit, well-controlled risk factors	Direct inclusion in the standard program, with monitoring according to the general protocol
High risk	Documented polyvascular disease without active instability; or a single territory with moderate functional impairment (residual ischemia, moderate neurological deficit, severe claudication)	Inclusion with enhanced monitoring, prioritization of precautions based on the most vulnerable territory, more frequent reassessment

Risk Category	**Guidance criteria for classification (integrated assessment across the three domains)**	**Implications for inclusion in the program**
Very high risk	Multivessel disease with unstable or recently decompensated involvement in one territory; recent multiple revascularizations; severe associated comorbidities (advanced renal failure, heart failure)	Strictly supervised initiation, typically in the early stages at a reduced intensity, with the explicit involvement of all relevant specialties prior to prescribing
Temporary contraindication	Active instability in any of the three territories	Postpone inclusion until stabilization, with a scheduled reevaluation

Practical note: *In patients with multivessel disease, the final risk category assigned must always reflect the most severe level of risk identified in any of the assessed territories, not an average of them.*

Summary: *The initial evaluation of a patient with extensive atherosclerotic disease combines a medical history and clinical examination focused on all three territories, a minimal set of laboratory and imaging tests (including echocardiography and, if indicated, vascular Doppler ultrasound), dominance-specific functional assessment, and, finally, an explicit stratification of overall risk, which must be completed prior to any decision regarding enrollment in a rehabilitation or physical training program.*

8. REHABILITATION IN PATIENTS WITH CHRONIC CORONARY SYNDROME (CCS)

The term "chronic coronary syndrome" (CCS), introduced by the ESC guidelines to replace the older term "stable coronary artery disease," refers to a broad spectrum of clinical presentations of atherosclerotic coronary artery disease that are in a relatively stable phase of their natural course but remain at risk, at any time, to the risk of acute destabilization in the form of an acute coronary syndrome. This category includes both patients with stable chronic angina and asymptomatic patients who have had an acute coronary event or revascularization in the past, regardless of the technique used (PCI or CABG); all of these patients constitute, by definition, the primary target population for cardiovascular rehabilitation programs.

- **Objectives of the rehabilitation program for patients with ACS**
    - improvement of functional capacity and exercise tolerance, as assessed by exercise testing or field tests;
    - to reduce angina symptoms at a given level of exertion through the central and peripheral mechanisms of physical training;
    - optimizing control of cardiovascular risk factors, particularly lipid, blood pressure, and blood glucose levels;
    - reducing the risk of recurrent coronary events and the readmission rate;
    - supporting social and occupational reintegration and improving the patient's perceived quality of life.
- **Indications for inclusion in the program**
    - post-myocardial infarction, with or without associated revascularization;
    - post-percutaneous coronary intervention (PCI), whether elective or performed in the context of acute coronary syndrome;
    - post-coronary artery bypass grafting (CABG);
    - chronic stable, symptomatic angina, under optimal medical treatment;
    - asymptomatic patients with coronary artery disease documented by angiography or noninvasive imaging who wish to optimize their functional capacity and risk profile.

Table 85 . Specific contraindications for physical training in patients with CCS

Absolute contraindications	Relative contraindications
Unstable angina, not controlled by medication	Controlled angina, but with a very low ischemic threshold on testing
Acute myocardial infarction, within the first 2–3 days	Controlled supraventricular arrhythmias without hemodynamic impact
Unstable, uncontrolled ventricular arrhythmias	Uncontrolled hypertension at the time of evaluation
Active decompensated heart failure	Moderate-to-severe, uncorrected anemia
Severe, symptomatic aortic stenosis	Significant, uncorrected metabolic or electrolyte disturbances

- **Safety threshold and individualization of exercise intensity**

In patients with CHF, the safety threshold for exercise is ideally established through an exercise test (standard or cardiopulmonary), which identifies the heart rate and level of exertion at which objective signs of myocardial ischemia or other risk signals occur. The detailed principles for tailoring exercise prescriptions based on test results—including the essential distinction between a limitation caused by a true ischemic threshold and one caused by other factors (peripheral, muscular)—are principles that are fully applicable to patients with CCS not complicated by multivessel disease.

- **Structuring the training program based on the results of the exercise test**

In patients with chronic coronary syndrome, the design of the exercise program is based directly on the maximum tolerated heart rate (MTHR) and the ischemic threshold identified during exercise testing—principles of individualization that are reiterated here with an emphasis on their practical application specific to this patient population.

Table 86 . Structuring exercise for patients with chronic coronary syndrome based on exercise testing

Program Stage	Intensity benchmark	CCS-Specific Note
Initial phase (first 2–3 weeks)	50–60% of MTF or 20–25 bpm below the ischemic threshold	Conservative progression, especially in patients with documented residual ischemia
Progression phase (weeks 4–8)	60–75% of MTF or 15–20 bpm below the ischemic threshold	Escalation contingent on the absence of symptoms and signs of instability
Consolidation phase (after week 8)	70–85% of MTF, in patients without documented residual ischemia	In patients with residual ischemia, the upper limit remains that established during testing, regardless of the phase of the program

- ✓ In patients with documented residual ischemia, exercise intensity must be set below the ischemic threshold identified during the exercise test, with a safety margin—a classic principle of cardiovascular rehabilitation—but with additional caution warranted by the specific context of diffuse coronary artery disease that has not been fully resolved by revascularization. Furthermore, the heart rate ceiling remains fixed throughout Phase II; any increase in this limit requires a formal reassessment via repeated exercise testing, not merely an extrapolation based on the patient's apparently good subjective tolerance.
- ✓ In patients without objective residual ischemia (complete testing, with no signs of ischemia at any intensity), progression may follow the general principles of gradual intensity increase, guided by the Borg score and subjective tolerance, without an artificially imposed ischemic ceiling.

Practical note: *Periodic reassessment via exercise testing—at the end of Phase II and subsequently as indicated by the cardiologist—is essential to allow for a justified increase in the intensity ceiling as the patient's functional capacity or ischemic status changes over time.*

Table 87 . Benefits and expected outcomes of physical training in patients with CCS

Area	Expected outcome, documented in the literature
Functional capacity	Significant increase in peak VO2 and distance on field tests
Angina symptoms	Reduction in the frequency and severity of angina episodes during equivalent exertion
Rehospitalization	Reduced readmission rate for cardiovascular causes
Mortality	Documented reduction in cardiovascular mortality among patients who complete a structured program
Quality of life	Consistent improvement, as reported through specific or general questionnaires

Practical note: *The benefits listed above are contingent upon program completion and long-term adherence; a program that is discontinued early or followed only partially provides only a fraction of the functional and prognostic benefits documented for a complete program.*

- **Post-PCI Considerations**

Post-PCI, mobilization can generally begin early, with attention paid to the vascular puncture site (femoral or radial), where local complications (hematoma, pseudoaneurysm) may occur, which are relevant to the type of exercise tolerated in the first few days.

- **Post-CABG Considerations**

Post-CABG, standard sternal precautions apply (avoiding arm strain and heavy lifting for 6–8 weeks), as detailed extensively in materials on cardiac surgery; additionally, for patients with a venous graft harvested from the lower limb, attention must be paid to mobilization and edema of that limb.

Summary: *Recovery in patients with chronic coronary syndrome pursues clear objectives—functional capacity, symptom control, and reduced risk of recurrence—applicable to patients who have undergone PCI, CABG, or who have stable chronic angina, with exercise intensity tailored to the safety threshold established during testing and with consistently documented benefits, which are, however, contingent upon the completion and long-term continuation of the program.*

9. REHABILITATION IN PATIENTS WITH PERIPHERAL ARTERY DISEASE (PAD)

- **Objectives of the rehabilitation program for patients with PAD**
  - to increase the pain-free walking distance and the maximum walking distance;
  - to improve quality of life, which is often significantly affected by the functional limitations caused by claudication;
  - to reduce the associated systemic cardiovascular risk, given that PAD is a marker of atherosclerosis;
  - preventing progression to more severe forms of the disease, including critical limb ischemia.
- **Indications for inclusion in the program**
  - intermittent claudication, Fontaine stage I–IIb, regardless of associated pharmacological or interventional treatment;
  - post-peripheral revascularization (endovascular or surgical), to optimize functional outcomes;
  - patients with increased systemic cardiovascular risk, for whom PAD management represents an opportunity for integrated intervention on overall risk,

Table 88 . Specific contraindications for physical training in patients with PAD

Absolute contraindications	**Relative contraindications**
Critical limb ischemia, untreated	Insufficiently controlled ischemic rest pain
Active, uncontrolled ulcers or foot infection	Severe joint comorbidities that limit walking independent of PAD
Associated, uncontrolled cardiac instability	Severe peripheral neuropathy with an increased risk of undetected lesions
Recent acute, untreated thrombosis	Moderate-to-severe, uncorrected anemia

- **Safety threshold in patients with PAD**

In patients with isolated PAD, the safety threshold for walking exercise is primarily determined by the onset of moderate-to-severe claudication pain—a functional, not cardiac, threshold—which guides the classic structure of exercise-rest cycles. However, in patients with PAD associated with coronary- y disease, the cardiac threshold identified during exercise testing remains the priority and must be adhered to regardless of the patient's apparently superior peripheral tolerance to walking.

- **Structuring the Training Program Based on the Claudication Threshold**

Unlike in cardiac patients, for whom the training program is structured based on the maximum tolerated heart rate and the ischemic threshold, in patients with isolated PAD, the central parameter for structuring the program is the distance or walking time until the onset of claudication pain, as determined by a standardized walking test (on a treadmill, using a graded protocol, or the 6-minute walk test, when treadmill testing is not available).

Table 89 . Exercise test parameters in patients with PAD and their use in program design

Parameter measured during testing	Significance	Use in program design
Pain-free walking distance (initial claudication)	The distance at which the first discomfort occurs in the lower limb	The point at which each active walking interval begins within the effort-rest cycle
Maximum walking distance (limiting claudication)	The distance at which pain becomes intense enough that the patient is forced to stop	The point at which walking is extended before a rest, in the classic training protocol
Pain recovery time	The time required for pain to subside during the rest period	Guides the duration of the rest period between cycles so that walking can resume at an acceptable level of discomfort

Progression of the cardiovascular rehabilitation program for patients with isolated PAD is achieved by gradually increasing either the total duration of the session or the number of exertion-rest cycles, while consistently adhering to the principle of stopping at a level of moderate-to-severe pain, not by increasing walking speed beyond a comfortable pace. In patients with PAD associated with coronary artery disease, this claudication-based structure remains valid only within the heart rate ceiling established by the ischemic threshold; in other words, the claudication threshold guides the duration and structure of the cycles, but the heart rate threshold remains the absolute upper limit of intensity.

Practical note: *In patients with PAD without known coronary artery disease, but with significant cardiovascular risk factors, the absence of an explicit cardiac stress test should not be assumed to indicate the absence of coronary risk—screening for asymptomatic atherosclerotic disease in other areas remains relevant before designing a program based exclusively on the claudication threshold.*

Table 90 . Benefits and expected outcomes of the program for patients with PAD

Area	Expected outcome, documented in the literature
Walking distance	Significant increase in pain-free walking distance and maximum walking distance after at least 12 weeks of the program
Quality of life	Consistent improvement, as reported by questionnaires specific to peripheral arterial disease
Need for revascularization	Possible reduction or postponement of the need for a revascularization procedure in some patients
Systemic cardiovascular risk	Indirect benefit, through improved overall physical activity levels and the opportunity for active risk factor management

Practical note: *The benefit of walking training for patients with PAD is dose-dependent: the most robust results come from programs lasting at least 12 weeks and involving at least 3 sessions per week; shorter or less frequent programs generally offer more modest functional benefits.*

- **Structuring the Supervised Walking Program**

The classic protocol involves walking until moderate-to-severe pain occurs, followed by a short rest, then resuming walking; this cycle is repeated during a 30- to 60-minute session, 3 to 5 times a week, for a minimum of 12 weeks, to achieve maximum functional benefit.

- **Recovery Following Peripheral Revascularization**

Following peripheral revascularization, regardless of the technique used (endovascular or surgical), resuming supervised walking—whenever possible—further improves functional outcomes, and the combination of the two interventions is superior to either one used in isolation.

- **Management of Wounds and Critical Ischemia**

In patients with tissue damage (Fontaine stage IV), the priority is wound care and, often, urgent revascularization; the exercise program is severely limited or postponed until local stabilization is achieved, a decision that must be made in close collaboration with the vascular surgeon.

- **Resistance Training in Patients with PAD**

Although walking training remains the central intervention, complementary lower-limb resistance training can further improve muscle strength and, indirectly, walking distance, and is particularly useful in patients who initially cannot tolerate the walking volume required by the standard protocol.

Table 91 . Alternatives to classic supervised walking

Alternative	Typical Indication
Upper-limb exercise bike training	Patients with severe walking limitations or joint comorbidities
Structured home-based training with remote monitoring	Patients without easy access to a supervised program at a center
Treadmill walking with partial weight-bearing	Patients at risk of falls or with significant joint limitations

Practical note: *Alternatives to traditional supervised walking should be considered when the standard protocol is not tolerated or accessible, but they should not, without clear justification, replace the intervention with the strongest level of evidence in patients who can actually tolerate it.*

Summary: *Rehabilitation in patients with peripheral arterial disease aims, first and foremost, to increase walking distance and improve quality of life through a structured, adequately dosed program, whose safety threshold is determined by claudication in isolated cases but remains subordinate to the cardiac threshold when PAD coexists with coronary artery disease.*

10. POST-ISCHEMIC STROKE RECOVERY – CARDIOVASCULAR COMPONENT

- **Objectives of the cardiovascular component in post-stroke patients**
  - improvement of overall aerobic capacity, which is often severely reduced even during the acute phase due to immobilization;
  - to reduce the risk of recurrent stroke and other cardiovascular events by controlling common risk factors;
  - providing complementary support for overall functional recovery—motor, cognitive, and balance;
  - prevention of deconditioning secondary to prolonged immobilization, which is particularly common in the early post-event phases.
- **Indications for the cardiovascular component of rehabilitation**
  - Minor or moderate ischemic stroke, neurologically stable, well past the acute phase;
  - absence of associated cardiac contraindications for exercise (assessed according to the general principles of cardiovascular rehabilitation);
  - ability to follow basic instructions, with or without the support of a family member or a member of the neurological rehabilitation team.

Table 92 . Specific contraindications for physical training in post-stroke patients

Absolute contraindications	**Relative contraindications**
Recent, uncontrolled hemorrhagic stroke	Severe aphasia, with no ability to communicate warning signs
Active hemodynamic instability	Moderate cognitive impairment affecting the ability to understand safety instructions
Significant, active cerebral edema	Unstable cardiac comorbidities, currently under evaluation
Progressive, unstabilized neurological deterioration	Severe risk of falls, with no additional safety measures available

- **Safety Threshold and Supervision in Post-Stroke Patients**

In post-stroke patients, the safety threshold for exercise is not determined solely by the cardiovascular response to exertion, but also by neurological tolerance—fatigue, risk of falling, and coordination ability—which may become the dominant limiting factor before any cardiac signals. Formal exercise testing in these patients may be limited by motor deficits or general fatigue, rather than by an actual ischemic threshold—as in patients with claudication—and this requires the same caution in interpretation: an early termination due to non-cardiac causes does not automatically rule out good cardiac reserve, nor does it confirm it.

- **Structuring the Exercise Program Based on Exercise Test Results**

In post-stroke patients, structuring the program based on exercise testing is less straightforward than in classic cardiac patients: frequently, the test is terminated due to generalized muscle fatigue, lack of coordination during exercise, or anxiety related to balance—not because of an objective cardiac signal—which means that the recorded **maximum tolerated heart rate (MTHR)** often reflects the patient's neurological or functional limit, not necessarily an actual cardiac limit.

Table 93 . Structuring post-stroke training based on exercise testing

Exercise Test Findings	Interpretation	Program Design
MTHR limited by an objective cardiac finding (ischemia, arrhythmia)	There is a real cardiac ceiling, similar to that discussed in the patient with CCS	The training heart rate is set with a safety margin below this threshold
MTHR limited by muscle fatigue, imbalance, or anxiety, with no cardiac signs until cessation	The actual cardiac reserve most likely remains unaffected by the test; the limit is functional, not cardiac	Intensity is guided primarily by the Borg scale and functional tolerance (balance, coordination), with a slow progression in duration before increasing intensity
Incomplete or inconclusive test due to severe motor/cognitive deficits	The information obtained is limited; the actual cardiac risk remains partially unknown	Program with low initial intensity, continuous monitoring, and frequent functional reassessment instead of a formal exercise test

Practical note: *In post-stroke patients, the absence of a cardiac signal during exercise testing should not be interpreted as "excellent cardiac reserve," but rather, in most cases, as "cardiac reserve not reached due to functional limitations"—a distinction that is essential to avoid increasing intensity based on an unjustified assumption.*

Table 94 . Benefits and expected outcomes of the program for post-stroke patients

Area	Expected outcome, documented in the literature
Aerobic capacity	Improvement in peak VO_2 (the highest oxygen consumption value reached during maximal exertion) and distance covered in the 6-minute walk test
Functional recovery	Possible positive impact on certain aspects of motor and cognitive recovery, complementary to standard neurological recovery
Risk of recurrence	Reduced risk of stroke recurrence through control of associated risk factors
Quality of life and mental well-being	Improved quality of life and reduced depressive symptoms commonly associated with the post-stroke period

Practical note: *The body of evidence supporting the benefits of post-stroke aerobic exercise, although steadily growing, remains smaller than that accumulated for the general cardiac population; therefore, treatment goals should be communicated to the patient with a realistic perspective, without overstating benefits that have not yet been sufficiently quantified for each individual functional aspect.*

- **Integrating Cardiovascular Rehabilitation with Neuromotor Rehabilitation**

The cardiovascular component of post-stroke rehabilitation must be integrated—not added separately—into the neuromotor rehabilitation program, with explicit coordination between the physical therapist specializing in neurological rehabilitation and the cardiovascular rehabilitation team, to avoid both overexertion and underutilization of the patient's actual functional capacity.

- **Post-Stroke Aerobic Exercise—Evidence and Specifics**

Post-stroke aerobic training, tailored to residual functional capacity, improves both cardiovascular fitness and, in some patients, certain aspects of motor and cognitive recovery, with an acceptable

safety profile in neurologically stable patients, although the body of evidence is still more limited than in the general cardiac population.

- **Specific Precautions**
  - spasticity — may limit the type of exercise tolerated and require adaptation of equipment or technique;
  - cognitive deficits — may affect the patient's ability to follow complex instructions or recognize warning signs;
  - Risk of falling — significantly increased in patients with residual motor deficits, requiring adaptation of the exercise environment and close supervision.
- **Adaptation of Equipment and the Exercise Environment**

For patients with residual motor deficits, standard exercise equipment (exercise bike, treadmill) may require specific adaptations—pedals with a strap for the affected leg, additional handrails, closer supervision—and the choice of exercise type must explicitly account for these limitations, rather than following a standard protocol identical to that used for patients without neurological deficits.

- **Communication with Patients with Aphasia or Cognitive Impairment**

For patients with aphasia or significant cognitive deficits, instructions must be simplified, repeated constantly, and, whenever possible, supported by direct visual demonstration rather than complex verbal explanations; furthermore, assessment of the patient's understanding of safety instructions (warning signs, stopping the exercise) must be actively confirmed, not assumed.

Summary: *Post-stroke cardiovascular rehabilitation must be explicitly integrated with neuromotor rehabilitation, taking into account specific precautions related to spasticity, cognitive deficits, risk of falls, and, when necessary, communication difficulties, without compromising the documented benefits of aerobic exercise for secondary prevention and, possibly, for overall functional recovery.*

11. NUTRITION IN PATIENTS WITH MULTIVASCULAR ATHEROSCLEROTIC DISEASE

- **Nutritional Principles Common to All Three Regions**

The Mediterranean-style diet, characterized by a high intake of vegetables, fruits, whole grains, fish, and olive oil, along with a reduction in saturated fats, has been associated with a reduction in cardiovascular events across a wide range of populations, including patients with documented coronary, cerebrovascular, and peripheral artery disease, which is why it represents the basic, common nutritional recommendation for patients with multivascular disease, regardless of the area initially affected.

- **Nutritional Considerations for Post-Stroke Patients**

In post-stroke patients, an assessment of swallowing function is essential before any specific nutritional recommendations are made, and the presence of dysphagia can significantly limit the types of foods that can be tolerated, requiring active collaboration with a swallowing specialist and, if necessary, adjustments to the texture of recommended foods.

- **Weight Management in Patients with PAD**

In patients with BAP who are overweight, weight loss can indirectly improve walking distance by reducing the metabolic demand of walking, complementing specific training through supervised walking.

- **Sarcopenic obesity and emerging therapies (ESC 2026 guidelines)**

The 2026 ESC Guidelines introduce sarcopenic obesity as a distinct clinical entity, defined by the coexistence of excess adipose tissue with reduced skeletal muscle mass and function, conceptually distinct from both obesity and isolated sarcopenia. This condition is associated with a significantly increased risk of major cardiovascular events, coronary artery disease, and stroke, compared to individuals with normal body composition, and is particularly relevant in elderly patients with vascular disease, who are simultaneously at risk for post-stroke sarcopenia and excess weight associated with a sedentary lifestyle induced by claudication.

- Active screening for malnutrition, sarcopenia, and sarcopenic obesity, using standardized protocols, is recommended for patients enrolled in a rehabilitation program to enable early detection;
- Assessment of body composition—not just body mass index in isolation—is recommended for all patients undergoing rehabilitation;
- GLP-1 receptor agonists, combined with lifestyle interventions, may be considered for patients with a body mass index (BMI) $\geq$ 27 kg/m² and high cardiovascular risk or documented atherosclerotic disease, to reduce weight and major cardiovascular events;
- Nutritional interventions with increased protein intake are recommended to prevent muscle mass loss in patients undergoing weight-loss treatment as part of their recovery;
- Referral for bariatric surgery may be considered after completion of the recovery program in patients with a body mass index (BMI) $\geq$ 35 kg/m², when lifestyle interventions have not resulted in sustained weight loss.

Practical Note: *In patients with multiple vascular conditions, particularly those with BAP or post-stroke sarcopenia, the nutritional goal should not be merely weight loss, but the active maintenance of muscle mass through resistance training combined with adequate protein intake—a principle already discussed in relation to cardiac cachexia in other materials in this course, now expanded by the 2026 ESC guidelines to the broader concept of sarcopenic obesity.*

Summary: *The basic nutritional principles remain common to the three vascular domains discussed in this manual, with the Mediterranean-style diet being the central recommendation, requiring specific adaptations for patients with post-stroke dysphagia, who are overweight with BAP or have sarcopenic obesity—a condition recently formalized by the ESC 2026 guidelines, which expand available interventions to include active screening and, in selected cases, adjunctive pharmacological or surgical therapies.*

12. INDIVIDUALIZED RECOMMENDATIONS FOR PHYSICAL TRAINING IN PATIENTS WITH MULTIVESSICULAR ATHEROSCLEROTIC DISEASE

- **FITT Principles Applied Across the Three Domains**

For patients with documented involvement in multiple domains, the FITT prescription must simultaneously adhere to the most restrictive safety threshold among those imposed by each affected domain—not an average of them—an essential principle to remember in order to avoid a dangerously optimistic prescription.

Table 103. Hierarchy of precautions when multiple conditions coexist

Combination	Dominant precaution
CCS + PAD	The coronary ischemic threshold generally limits the maximum intensity; walking, however, remains the key intervention for BAP
CCS + Stroke	Neurological considerations (balance, cognition) determine the type of exercise; aerobic intensity adheres to the coronary threshold
Stroke + PAD	The risk of falling, exacerbated by claudication, requires additional supervision during walking

- **Guideline for the structure of a session for patients with complex vascular conditions**

A typical session may combine a supervised walking component (for PAD), at an aerobic intensity that adheres to the coronary threshold identified through testing, with balance and coordination exercises (relevant for patients with neurological sequelae), in a sequence that avoids overlapping the most demanding components.

The order and duration of the components are not arbitrary: each sequence of the session must explicitly address an objective related to a specific area, and the transition between components must allow for a partial recovery of heart rate before introducing an element with a different level of exertion (for example, the transition from walking to static balance exercises, which involve a qualitatively different type of effort).

Table 95 . Suggested structure of a session for patients with complex vascular disease

Sequence	Approximate duration	Main objective / target area	Parameter to monitor
Warm-up	5–10 minutes	Progressive cardiovascular adaptation, joint mobilization	Resting heart rate, absence of discomfort
Supervised walking component	15–30 minutes (with breaks when claudication occurs)	PAD—improvement in walking distance through exercise-rest cycles	Heart rate (below the coronary threshold), Borg scale score, onset/intensity of claudication
Balance and coordination exercises	10–15 minutes	Post-stroke neurological sequelae – reducing the risk of falls	Postural stability, level of assistance required, fatigue
Endurance training (optional)	10–15 minutes	General muscle strength, support for walking	Proper form, absence of pathological compensations
Cool-down / relaxation	5–10 minutes	Normalization of cardiovascular parameters before the end of the session	Heart rate, blood pressure, residual symptoms

- **Guideline example for a patient with CCS + PAD + mild post-stroke sequelae**

For a patient with involvement of all three vascular territories, the indicative structure above can be adapted as follows: prolonged warm-up (10 minutes, given the risk of residual chronotropic incompetence), a walking component explicitly limited to a target heart rate established by exercise testing (e.g., below 110 bpm, if that is the identified ischemic threshold), with interruptions mandated either by claudication or by reaching the target heart rate, whichever occurs first; balance exercises performed exclusively in a seated or supported position, if the risk of falling is considered significant; and a longer-than-standard recovery period, with explicit blood pressure monitoring prior to discharge from the session.

Practical note: *For patients with impairment in all three domains, the sequencing of the session must always begin with the most restrictive precaution identified during the initial assessment (typically, the coronary ischemic threshold), with the other components structured "around" this limit, rather than added later as independent elements.*

Practical note: *In patients with multi-vessel disease, the theory that they require "greater caution than the sum of the individual cautions" is not always correct: some precautions are cumulative, but others (for example, the benefit of walking for BAP) remain equally relevant, even if the intensity must be reduced for coronary reasons.*

- **The Role of Exercise Testing in Patients with Multivessel Disease**

In patients with concurrent coronary and peripheral artery disease, exercise testing must be interpreted with double caution: an early termination due to claudication does not rule out the presence of coronary ischemia at a higher intensity—one that was not reached due to peripheral limitations—a situation that may require supplementing the evaluation with alternative methods (e.g., pharmacological stress testing) for accurate coronary risk stratification.

- **What does the "safety threshold" established by the exercise test mean?**

The safety threshold refers to the intensity of exercise, expressed as heart rate, beyond which the exercise test revealed an objective sign of risk: ST-segment depression suggestive of ischemia, the onset of a significant arrhythmia, an abnormal blood pressure response, or, in a patient with BAP tested on a treadmill, reaching the claudication threshold. This threshold is not a theoretical value, but an individual benchmark, measured directly during testing, beyond which the probability of an adverse event during exercise increases significantly. The safety threshold represents the maximum exercise intensity at which the patient can exercise without risk.

The **maximum tolerated heart rate (MTHR)** obtained during testing—that is, the heart rate reached at the point the test was stopped, regardless of the reason for stopping—is the concrete benchmark from which the training heart rate is subsequently derived. The essential distinction for the polyvascular patient is between an MTHR limited by an objective sign of myocardial ischemia and an MTHR limited by a purely peripheral factor (claudication, muscle fatigue), since the clinical significance—and, by extension, the applied safety margin—differs fundamentally between the two situations.

Table 96 . Prescribing physical training based on exercise test results

Exercise test result	Interpretation	Customization of the training program
MTHR limited by an objective ischemic threshold (ST-segment depression, typical angina)—residual ischemia present	There is a true cardiac ceiling, below which the risk of an ischemic event is low, and above which the risk increases significantly	The training heart rate is set with a safety margin of approximately 10–15 bpm below the heart rate at which the ischemic sign appeared, regardless of whether this threshold was actually reached by claudication during the same test
MTHR limited exclusively by claudication, with no ischemic signs until termination—coronary ischemia not ruled out at higher intensities	The test did not "exhaust" the coronary reserve; a true ischemic threshold may exist at a higher heart rate, which was not reached due to peripheral limitation	The training heart rate cannot be automatically extended to the recorded FMHR; it is recommended to complete the evaluation (pharmacological stress testing or another imaging method) before increasing the intensity beyond the FMHR obtained in the claudication-limited test
Complete testing (maximal exertion or symptom-limited by generalized muscle fatigue), with no ischemic signs at any intensity—no objective residual ischemia	The absence of an identifiable ischemic threshold suggests good coronary reserve at the tested intensity	Prescription can be guided by general intensity principles (heart rate zones/Borg scale), without an artificial ischemic ceiling; however, the limitations imposed by other factors (claudication, balance) remain valid

- **Practical note:** *A test that is "negative" for ischemia but terminated early due to claudication is not equivalent to a completely negative test: the correct label is "no detectable ischemia up to heart rate X," not "no ischemia," and the prescription should be formulated accordingly, with the caution warranted by an incompletely assessed coronary reserve, pending further clarification.*

In patients in whom a subsequent evaluation (e.g., a pharmacological stress test) rules out significant residual ischemia, the heart rate ceiling initially imposed by the equivocal result of the claudication-limited test may be raised, and the individualized exercise program may subsequently be tailored exclusively according to the thresholds dictated by the other affected areas (e.g., based solely on walking tolerance and balance), without maintaining a coronary precaution that has since become unjustified.

- **Explicit Documentation of the Prescription Rationale**

In patients with multivessel disease, it is recommended that the prescription form explicitly document which precaution determined each limitation of the program (e.g., "intensity limited to a coronary threshold of X bpm" versus "walking duration limited by claudication"), thereby facilitating subsequent reassessment when one of the affected areas improves (for example, after additional revascularization).

- **Guideline for Assessing Benefit at Reevaluation (8–12 Weeks)**

To objectively assess the program's benefit in polyvascular patients, it is helpful for periodic reassessment to track, separately, a relevant indicator for each affected territory, thereby avoiding the erroneous conclusion that the patient's "overall improvement" automatically reflects uniform improvement across all territories.

Table 97 . Guideline for assessing benefit at reevaluation (8–12 weeks)

Area	Monitored indicator	Baseline value (example)	Value at reevaluation (example)	Guideline Interpretation
Coronary	Heart rate at the onset of the ischemic threshold during testing	115 bpm	128 bpm	Improved ischemic tolerance; possible increase in target training heart rate, with the cardiologist's approval
Peripheral	Walking distance to claudication	150 m	240 m	Positive response to walking training, as expected for this type of intervention
Cognitive	SPPB (Short Physical Performance Battery) score or Timed Up and Go time	SPPB 7/12	SPPB 9/12	Improved balance and functional mobility; reduced but not eliminated risk of falls

Practical note: *A benefit documented in a single domain (e.g., significant improvement in walking distance) should not be automatically extrapolated to the other two: each parameter in the table above must be reevaluated separately using the method specific to that domain, and the decision to intensify the program must be based on the overall set of these results, not just on the most favorable one.*

Summary: *Prescribing exercise for patients with polyvascular disease requires an explicit analysis of each affected territory's contribution to overall functional limitation, with clear documentation of the reasoning, to allow for proper adjustment of the program as the patient's clinical condition evolves.*

13. MONITORING AND WARNING SIGNS SPECIFIC TO EACH AFFECTED VASCULAR TERRITORY

In patients with multivascular disease, monitoring is not limited to the cardiac response to exercise. Each affected territory has its own warning signs, which may occur during the session or be reported by the patient between sessions. Recovery room staff must recognize them quickly and know the appropriate course of action for each situation.

13.1. Coronary Territory

What is monitored?

- heart rate, while adhering to the safety threshold established during the exercise test;
- blood pressure before the session, at peak exertion, and during the recovery period;
- Borg scale score at a fixed reference workload, compared from one session to the next;
- heart rhythm: via ECG telemetry in patients at moderate or high risk, and in others via pulse palpation or pulse oximeter.

Warning signs during the session

- chest pain or angina-like symptoms: discomfort, pressure, or burning sensation behind the breastbone; pain radiating to the jaw, arm, or epigastrium;
- shortness of breath disproportionate to the level of exertion;
- newly developed arrhythmias, frequent or clustered extrasystoles, sustained palpitations;
- a drop in systolic blood pressure of more than 10 mmHg with increased exertion;
- excessive increase in blood pressure: systolic over 250 mmHg or diastolic over 115 mmHg;
- cold sweats, pallor, dizziness, or presyncope;
- heart rate significantly higher than the usual rate for the same level of exertion.

Symptoms reported between visits

- angina occurring with less exertion than before or at rest (unstable angina);
- episodes of palpitations, syncope, or presyncope;
- a noticeable decrease in exercise tolerance during daily activities.

Management

- in case of chest pain or arrhythmia: the session is stopped immediately, the patient is seated or laid down, blood pressure (BP) and heart rate (HR) are measured, and the doctor is notified.
- If the pain does not subside within a few minutes of rest, or after sublingual nitroglycerin when prescribed, call 112.
- The patient must not resume training until medically reevaluated.

13.2. Cerebrovascular System

What is monitored?

- Blood pressure before each session. For patients with a history of stroke or transient ischemic attack (TIA), blood pressure monitoring is essential. The session is postponed if resting blood pressure exceeds the limits set by the doctor, typically 180/110 mmHg;
- baseline neurological status: limb strength, speech, and balance. These are noted during the initial evaluation so that any new changes can be recognized;
- Heart rhythm, especially in patients with atrial fibrillation, who are at increased risk of embolism.

Warning signs (**BE-FAST rule**)

- Balance: sudden loss of balance, vertigo, or new-onset unsteady gait;
- Eyes: sudden vision problems, such as loss of vision in one eye, double vision, or narrowing of the visual field;
- Face: facial asymmetry, with a crooked mouth or a “drooping” corner of the mouth;
- Arm: sudden weakness or numbness in an arm or leg, usually on one side of the body;
- Speech: slurred speech, difficulty finding words, or difficulty understanding what is being said;

- Time: Note the time the symptoms began immediately, as emergency treatment depends on it.

Other warning signs (even if they disappear completely, they may indicate a stroke and require urgent evaluation).

- a sudden, severe, unusual headache, described as "the worst headache ever";
- sudden confusion, drowsiness, or behavioral changes;
- transient episodes of neurological deficit that resolve spontaneously within a few minutes.

Management

- Any new neurological sign is a medical emergency: stop the session, position the patient safely in a sitting or lying position, note the time of onset, and immediately call 112.
- The patient should not be given anything by mouth due to the risk of aspiration if they have swallowing difficulties.
- Even if the symptoms disappear, the patient must not be sent home without a medical evaluation.

13.3. Peripheral Arterial System

What is monitored?

- The distance or walking time until claudication occurs and the maximum walking distance, compared from one session to the next;
- the intensity of claudication pain, on a scale from 0 to 4 or from 0 to 10;
- peripheral pulses, skin color, and temperature in the lower extremities;
- the condition of the skin on the feet, especially in diabetic patients: lesions, blisters, ulcers, and pressure points caused by footwear.

Chronic warning signs (disease progression)

- progressive shortening of the claudication distance;
- the onset of rest pain, especially at night, which improves when the leg is dangled over the edge of the bed;
- skin lesions that do not heal, ulcers, or discoloration of the toes.

Acute warning signs (acute limb ischemia, the "6P" rule)

- severe, sudden-onset pain (*pain*);
- pallor or coldness of the limb (*pallor*, *poikilothermia*);
- new-onset absence of a peripheral pulse (*pulselessness*);
- paresthesia: numbness or tingling (*paresthesia*);
- motor deficit, up to paralysis of the limb (*paralysis*).

Management

- In typical claudication, the patient stops walking until the pain subsides, then resumes walking according to the exercise protocol.
- In cases of progressive worsening, the patient is referred for reevaluation by the attending physician or vascular surgeon.
- In cases of acute limb ischemia, the session is stopped immediately and emergency services (112) are called. The limb should not be elevated, massaged, or actively warmed.

13.4. Aortic Region (if the patient has a known aortic aneurysm)

What should be monitored?

- Blood pressure: Avoid large increases in blood pressure during exertion;
- Strength training technique: Avoid the Valsalva maneuver—that is, straining while holding your breath—and lifting heavy weights.

Warning signs

- sudden, intense abdominal, lower back, or chest pain, sometimes described as "tearing";
- dizziness, pallor, cold sweats, or syncope—signs of a sudden drop in blood pressure.

Management—the session is stopped immediately, the patient is laid down, and emergency services (112) are called.

13.5. General Recommendations for Patients with Multivascular Disease

- Before each session, a brief symptom questionnaire is administered: "Since your last session, have you experienced chest pain, dizziness, weakness in your arms or legs, speech or vision problems, or new pain in your legs?"
- The patient and family are instructed to recognize warning signs and call 112 without delay.
- Any new symptoms are recorded in the session monitoring form, including the time of onset, blood pressure (BP) and heart rate (HR) readings, and the actions taken.

Practical Note: *Rehabilitation unit staff working with multivascular patients must quickly recognize warning signs across all three categories, not just those associated with the patient's primary diagnosis, as an acute event can occur in any category, regardless of the initial reason for inclusion in the program.*

Table 98 . Guideline for escalation protocol, integrated across the three domains

Severity Level	Example	Management
Mild	Mild, disproportionate fatigue; claudication at the usual distance	Continue close monitoring; document the episode
Moderate	Atypical chest pain; mild, transient weakness in a limb; sudden worsening of claudication	Interrupt the session; prompt clinical evaluation
Severe	Typical chest pain; acute neurological deficit; severe pain with pallor in a limb	Activate the emergency protocol; arrange for emergency transport, if necessary

- **The role of specific emergency equipment**

In addition to standard cardiovascular emergency equipment (automated external defibrillator, emergency kit), units actively treating post-stroke patients or those with advanced BAP must have clear procedures for rapid access to a neurological or vascular emergency unit, with which there should ideally be a pre-established collaboration protocol.

14. INTENSIVE SECONDARY PREVENTION IN PATIENTS WITH MULTIPLE VASCULAR DISEASES

Patients with cerebrovascular disease, regardless of the site responsible for the initial clinical presentation, fall, by definition, into the very high cardiovascular risk category or, in some patients, into the extreme risk category, as defined by the ESC guidelines based on the recurrence of events despite optimal treatment. This classification is not merely a categorization but directly determines the intensity of therapeutic targets for each modifiable risk factor, discussed in detail in the following sections of this chapter.

Management of these patients must be multifaceted—simultaneously addressing lipid, glycemic, and blood pressure profiles, smoking status, and, when indicated, antiplatelet or anticoagulant therapy—and sustained over the long term, since the benefits of each individual intervention are cumulative, and neglecting a single factor can negate a significant portion of the benefit gained by controlling the others.

14.1. Intensive Optimization of the Lipid Profile

Current guidelines recommend increasingly stringent LDL-cholesterol targets for patients with documented atherosclerotic disease, regardless of region, and patients with multivascular disease fall, by definition, into the very high-risk category, justifying intensive lipid-lowering therapy, often in combination.

- **Lipid treatment targets according to the 2025 ESC/EAS guidelines**

The ESC/EAS guidelines for the management of dyslipidemia establish LDL-cholesterol targets that are strictly differentiated by risk category, with the general principle being "the higher the risk, the lower the target," and the percentage reduction from baseline is just as important as the absolute threshold.

- **LDL cholesterol is the primary therapeutic target in the management of dyslipidemia**

Table99 . LDL-cholesterol targets by risk category

Risk category	Guideline criteria for classification	LDL-cholesterol target	Minimum reduction from baseline
Very high risk	Documented atherosclerotic cardiovascular disease (CAD, stroke, PAD); diabetes with target organ damage; severe chronic kidney disease; SCORE2 ≥ 10%	< 55 mg/dl (< 1.4 mmol/l)	≥ 50%
Extreme risk (recurrence)	Second atherosclerotic cardiovascular event within 2 years, while on maximally tolerated lipid-lowering therapy (not necessarily in the same anatomical region)	< 40 mg/dl (< 1.0 mmol/l)	≥ 50%

Practical note: *The "extreme risk" category, with an LDL target below 40 mg/dL, is particularly relevant for the multivascular patient discussed in this chapter: a patient who has had a myocardial infarction followed, within 2 years, by a stroke or peripheral revascularization, that is, two atherosclerotic events—not necessarily in the same anatomical region—falls squarely into this category, even if each individual event was successfully treated.*

The treatment strategy for achieving these goals is phased:

1. initiation of a high-intensity statin at the maximum tolerated dose;
2. if the target is not met, adding ezetimibe;
3. for very high-risk patients who do not reach the target even with this combination, a PCSK9 inhibitor (monoclonal antibody or inclisiran) is added.

The 2025 update to the dyslipidemia guidelines also introduces bempedoic acid. It is used in patients who cannot tolerate statins or in whom statins alone are insufficient to achieve the target.

- **Secondary targets: non-HDL cholesterol and apolipoprotein B**

In patients with elevated triglycerides, diabetes, obesity, or metabolic syndrome, the calculated LDL-cholesterol value may underestimate the actual burden of atherogenic particles. For these patients, the ESC/EAS guidelines recommend two secondary targets:

- non-HDL cholesterol, calculated as the difference between total cholesterol and HDL cholesterol. It includes all atherogenic lipoproteins: LDL, VLDL, IDL, and Lp(a); it does not require a fasting blood sample.
- Apolipoprotein B (ApoB) directly reflects the number of atherogenic particles, since each atherogenic particle contains a single molecule of ApoB; it is considered the most accurate marker of atherogenic risk.

For very high-risk patients, the targets are:

- **non-HDL cholesterol below 85 mg/dl**
- **ApoB below 65 mg/dL**.

- **Triglycerides**

The guidelines do not establish a therapeutic target for triglycerides. A fasting level below 150 mg/dl (1.7 mmol/l) is associated with a lower cardiovascular risk, and levels above this threshold indicate the need to identify and correct secondary causes: obesity, uncontrolled diabetes, alcohol consumption, and certain medications.

- First-line treatment remains statins, along with lifestyle modifications: weight loss, reduction of alcohol and simple sugars, and physical activity.
- In high- or very high-risk patients whose LDL cholesterol is at target on statins but whose triglycerides remain **above 200 mg/dl** (2.3 mmol/l), the addition of a fibrate (fenofibrate or bezafibrate) **may be considered**; for this category of patients, the 2025 update to the guidelines recommends the addition of high-dose icosapent ethyl (2 × 2 g/day).
- Triglyceride levels above 880 mg/dl (10 mmol/l) increase the risk of acute pancreatitis and require priority treatment.

- **Lipoprotein (a) – Lp(a)**

Lp(a) is an atherogenic and prothrombotic lipoprotein. Its level is determined almost entirely by genetics, remains relatively constant throughout life, and is not significantly influenced by diet or physical activity.

- Testing: The 2025 update recommends that Lp(a) be measured at least once in a lifetime for every adult.
- Risk threshold: A value above 50 mg/dl (above 105 nmol/l) is considered a factor that increases cardiovascular risk. It can reclassify a patient with moderate risk into the high/very high-risk category. Very high levels, above 180 mg/dl (above 430 nmol/l), confer a risk comparable to that seen in heterozygous familial hypercholesterolemia.
- Therapeutic target: The guidelines do not establish a target for Lp(a). It has not yet been demonstrated that lowering Lp(a) reduces cardiovascular events, and specific therapies are currently being evaluated in clinical trials.
- Clinical Implication: In patients with elevated Lp(a), stricter control of other risk factors is recommended, primarily LDL cholesterol.

- **Apolipoprotein A-I and HDL cholesterol**
  - ApoA-I is the main protein in HDL particles (the guidelines do not recommend it as a therapeutic target or for routine risk assessment).
  - HDL cholesterol is used in the calculation of non-HDL cholesterol and the SCORE2 risk score, but it does not have a therapeutic target. Pharmacological increases in HDL cholesterol have not demonstrated cardiovascular benefits. In contrast, regular physical activity, weight loss, and smoking cessation moderately increase HDL cholesterol and remain recommended for their general health benefits.

- **Relevance to the Rehabilitation Program**

The cardiovascular rehabilitation program is an opportune time to assess each patient's complete lipid profile, determine their risk category and appropriate target, measure Lp(a) if it has never been measured, and inform the treating physician of the need to intensify treatment if the target has not been met.

14.2. Management of Hypertension

Strict blood pressure control reduces the risk of events in all three vascular territories discussed in this manual; this benefit is supported by extensive meta-analyses of antihypertensive intervention studies: a reduction of approximately 10 mmHg in systolic blood pressure is associated with a decrease of approximately 20% in major cardiovascular events, approximately 27% in stroke, approximately 17% in coronary artery disease, and approximately 28% in heart failure, regardless of the vascular territory that led to the patient's initial presentation."

Blood Pressure Targets According to the 2024 ESC Guidelines

The 2024 ESC Guidelines, dedicated to the management of elevated blood pressure and hypertension, introduce a paradigm shift compared to previous editions. A new category, "elevated blood pressure," is defined as 120–139/70–89 mmHg, distinct from hypertension proper (maintained at the classic threshold of ≥140/90 mmHg), intended to facilitate earlier initiation of interventions in individuals at high cardiovascular risk, such as patients with vascular disease.

Table 100 . Blood pressure targets according to the 2024 ESC guidelines

Category	Values (mmHg)	Recommended approach
Normal blood pressure	< 120/70	Maintain a healthy lifestyle
Elevated blood pressure	120–139 / 70–89	Lifestyle measures; medication considered in cases of increased cardiovascular risk
Hypertension	≥ 140/90	Medication, along with lifestyle measures

The most important practical change is the new treatment target: for most patients on antihypertensive therapy, the guidelines now recommend a systolic blood pressure of 120–129 mmHg as the first-line target, provided that the treatment is well tolerated—an "opt-out" approach to intensification, as opposed to the previous two-step "opt-in" model (first below 140/90, then, optionally, below 130/80). For elderly or frail patients, or those who cannot tolerate this threshold, the ALARA principle ("as low as reasonably achievable") applies, with an emphasis on the degree of frailty, not just chronological age.

Practical Note: *The guidelines also recommend broader use of blood pressure measurements outside the doctor's office (ambulatory or home monitoring with validated devices) to confirm the diagnosis and assess blood pressure control—an aspect that is also relevant to self-monitoring, as discussed in other chapters of this manual.*

- **Blood Pressure Control in Rehabilitation Practice**

Beyond the general therapeutic goals set by the attending physician, the rehabilitation team plays an active, complementary role in monitoring the blood pressure of patients with vascular disease: systematically checking blood pressure before, during (in higher-risk patients), and after each exercise session; recognizing an exaggerated blood pressure response to exercise; and encouraging adherence to lifestyle measures with documented effects on blood pressure—reducing sodium intake, engaging in regular physical activity, and maintaining a healthy weight.

- An exaggerated hypertensive response to exercise (a marked, disproportionate increase in systolic blood pressure) may signal inadequate blood pressure control at that time and should be reported to the treating physician, even if it does not require immediate interruption of the session;

- Orthostatic hypotension, common in elderly patients on multiple medications, must be actively monitored, especially during the transition from a lying or sitting position to standing, before beginning the walking component;
- In patients with a recent stroke, blood pressure control must be aligned with the specific recommendations of the neurology team, as the target blood pressure levels and the acceptable rate of blood pressure reduction may differ from those for patients with uncomplicated heart disease, particularly in the first few weeks following the stroke.

14.3. Diabetes Mellitus as an Accelerator of Atherosclerosis in All Vascular Territories

Diabetes accelerates the atherosclerotic process in all three areas discussed in this chapter, and diabetic patients with documented vascular disease in one area have a significantly increased risk of concomitant involvement in the other areas.

- **Glycemic Targets and Cardiovascular Management of Diabetes**

The ESC Guidelines for the Management of Cardiovascular Disease in Patients with Diabetes recommend a general glycated hemoglobin (HbA1c) target of less than 7%, though this should be individualized based on life expectancy and the risk of hypoglycemia: for patients with reduced life expectancy or significant frailty, a more permissive target of up to 8.5% is preferable, with priority given to therapeutic classes with proven cardiovascular benefits and a low risk of hypoglycemia.

Table 101 . Glycemic Targets (HbA1c) Based on Patient Profile

Patient profile	Guideline HbA1c Target	Note
Long life expectancy, without significant frailty	< 7.0%	Avoiding hypoglycemia remains a priority, especially in older adults
Reduced life expectancy or significant frailty	Up to 8.5%	Priority for therapeutic classes with proven CV benefit and low risk of hypoglycemia

A key change in the current guidelines, relevant for patients with multivascular disease, is the recommendation to combine an SGLT2 inhibitor and a GLP-1 receptor agonist in patients with diabetes and documented atherosclerotic cardiovascular disease, regardless of glycemic control and HbA1c levels—in other words, these classes are added to standard treatment for their direct cardiovascular benefit, not just for their hypoglycemic effect.

Practical Note: *For the rehabilitation team, the key practical message is that a diabetic patient with documented atherosclerotic disease should be in the absence of contraindications, on treatment with an SGLT2 inhibitor and/or a GLP-1 agonist, regardless of how well-controlled their blood glucose appears to be—the absence of these therapeutic classes in such a patient should be reported to the coordinating medical team and should not be assumed to be a deliberate therapeutic choice.*

14.4. Smoking—a cross-cutting impact across all three areas

Smoking cessation remains, for patients with vascular disease, one of the most effective interventions available, with documented benefits for coronary, cerebral, and peripheral risk simultaneously; for this reason, smoking cessation counseling should be offered systematically, regardless of the specific condition that led to the patient's inclusion in the program

Smoking acts through several mechanisms common to all vascular domains:

- endothelial dysfunction;
- oxidative stress and systemic inflammation;
- increased platelet aggregability and fibrinogen levels;
- vasoconstriction;
- decreased HDL cholesterol.

In peripheral artery disease, smoking is the strongest risk factor. Continuing to smoke after revascularization significantly increases the risk of bypass or stent occlusion and the risk of amputation. The ESC Prevention Guidelines recommend complete cessation of smoking, including avoiding secondhand smoke. Reducing the number of cigarettes is not sufficient, as even low-level smoking maintains a significant cardiovascular risk.
The most effective intervention combines:

- repeated behavioral counseling, beginning as early as the recovery program;
- pharmacological treatment: nicotine replacement therapy, varenicline, or bupropion;
- monitoring smoking status at each evaluation and resuming counseling in the event of a relapse.

14.5. Obesity in the Multivascular Patient—From Inflammation to Atherosclerosis

- **The obesity–inflammation–atherosclerosis relationship**

Obesity, especially abdominal (visceral) obesity, is not merely a "mechanical" risk factor. Visceral adipose tissue is an active endocrine organ. As it increases in volume, it becomes dysfunctional:

- hypertrophied adipocytes become hypoxic and release pro-inflammatory signals;
- adipose tissue becomes infiltrated with proinflammatory macrophages;
- cytokines are released into the circulation: TNF-α, interleukin 6 (IL-6), and interleukin 1β;
- IL-6 stimulates hepatic production of C-reactive protein, a marker of low-grade systemic inflammation;
- adiponectin levels decrease, which has anti-inflammatory and insulin-sensitizing effects;
- leptin levels rise, with pro-inflammatory and prothrombotic effects.

This low-grade chronic inflammation promotes atherosclerosis through several mechanisms:

- endothelial dysfunction, with reduced nitric oxide bioavailability;
- insulin resistance, leading to hyperinsulinemia and, over time, to type 2 diabetes;
- atherogenic dyslipidemia: elevated triglycerides, low HDL cholesterol, and small, dense LDL particles, which are highly atherogenic;
- a prothrombotic state, with increased PAI-1 and fibrinogen;
- hypertension, through activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system;
- atheromatous plaque instability, as inflammation promotes plaque rupture and acute events.

Adipose tissue surrounding the heart and blood vessels (epicardial and perivascular) plays a particular role. It acts locally on the vascular wall and the myocardium and contributes to the progression of coronary atherosclerosis and diastolic dysfunction.
For patients with multivessel disease, this link is essential: systemic inflammation associated with obesity simultaneously affects all vascular territories, just as smoking does.

- **Assessment of Body Composition**

The ESC Guidelines on Cardiovascular Prevention recommend assessing both overall weight and fat distribution:

Table 102 . Anthropometric parameters—target values and thresholds

Parameter	Target Values / Thresholds
Body Mass Index (BMI)	normal 20–25 kg/m²; overweight 25–29.9 kg/m²; obesity ≥ 30 kg/m²
Waist circumference – men	increased risk ≥ 94 cm; high risk ≥ 102 cm
Waist circumference – women	increased risk ≥ 80 cm; high risk ≥ 88 cm

(*Anthropometric parameter values are proposed by the WHO and adopted by the 2021 ESC guidelines for cardiovascular prevention)*

Waist circumference (WC) better reflects visceral fat than BMI and is more useful for estimating cardiometabolic risk. It is measured midway between the last rib and the iliac crest at the end of a normal exhalation.

In elderly patients or those with advanced chronic disease, muscle mass should also be assessed, for example, through grip strength, SPPB, or bioimpedance. The reason is sarcopenic obesity: increased fat combined with low muscle mass—a combination associated with a poor prognosis—which BMI may mask.

- **Weight Management Goals**
    - Weight loss of 5–10% of initial weight within the first 6–12 months. This is a realistic goal, with already significant metabolic and cardiovascular benefits.
    - Recommended rate: approximately 0.5–1 kg per week, through a caloric deficit of approximately 500–750 kcal per day.
    - Long-term maintenance of the achieved weight, which is the most difficult stage.
    - Preserving muscle mass during weight loss.
- **Therapeutic Interventions for Obesity**

1. Nutritional intervention
    - A moderate calorie deficit, tailored to the patient;
    - the Mediterranean diet, as recommended by the ESC prevention guidelines: vegetables, fruits, whole grains, legumes, fish, olive oil, and nuts, with a reduction in red and processed meats, simple sugars, and ultra-processed foods;
    - adequate protein intake, approximately 1.0–1.2 g/kg/day for older adults, if renal function permits, to prevent muscle mass loss;
    - reduced consumption of alcohol and sweetened beverages.
2. Physical Activity and Exercise
    - aerobic exercise: for weight loss and maintenance, volumes greater than the minimum preventive threshold of 150 minutes per week are usually required. As a guideline, 200–300 minutes per week of moderate-intensity exercise, achieved progressively, are recommended;
    - strength training 2–3 times per week, which is essential for maintaining muscle mass during a calorie deficit;
    - reducing sedentary time.

The cardiovascular rehabilitation program provides the ideal framework for this component, with supervised, progressive training tailored to the affected vascular territory. For example, in patients with claudication and obesity, the stationary bike reduces joint stress and is often better tolerated than walking.

3. Behavioral Support
    - setting concrete and realistic goals together with the patient;
    - self-monitoring: food diary, regular weigh-ins, pedometer;
    - family involvement;
    - identifying and treating associated disorders: depression, compulsive eating, sleep apnea.
4. Pharmacological treatment
    - GLP-1 receptor agonists (semaglutide) and dual GIP/GLP-1 agonists (tirzepatide) result in significant weight loss of approximately 15–20%.
    - The SELECT study showed that, in patients with atherosclerotic cardiovascular disease and obesity or overweight, without diabetes, semaglutide 2.4 mg weekly reduced major cardiovascular events by approximately 20%. Based on this , the 2024 ESC guidelines for chronic coronary syndromes recommend considering its use in patients without diabetes who have a BMI $\geq$ 27 kg/m².

- The 2026 ESC guidelines for heart failure include semaglutide and tirzepatide as add-on therapy for patients with HFpEF and obesity.
- Patients undergoing treatment with these agents must participate in resistance training and maintain an adequate protein intake, as part of the weight lost is muscle mass.

5. Bariatric Surgery

It is considered for patients with high cardiovascular risk and severe obesity, typically with a BMI ≥ 40 kg/m² or ≥ 35 kg/m² with comorbidities, when lifestyle interventions have not led to sustained weight loss.

- **Benefits of Weight Loss**

Even a 5–10% weight loss yields measurable benefits:

Table 103 . Benefits of weight loss

Area	**Benefit**
Blood pressure	Decrease of approximately 1 mmHg for every kilogram lost
Lipid profile	decrease in triglycerides, increase in HDL cholesterol, reduction in small, dense LDL particles
Carbohydrate metabolism	improvement in insulin resistance and HbA1c; with reductions of 10–15%, remission of type 2 diabetes is possible in some patients
Inflammation	decreased C-reactive protein and proinflammatory cytokines, increased adiponectin
Endothelial function	Documented improvement
Functional capacity	increased exercise tolerance and weight-adjusted peak VO2, reduced dyspnea
Heart failure	improvement in symptoms and quality of life
Sleep apnea	reduction in severity
Musculoskeletal system	Reduced joint stress, with improved mobility

- **Special Precautions**
  - "The obesity paradox": In some studies, patients with heart failure or coronary artery disease who were moderately overweight had an apparently better prognosis than those of normal weight. This primarily reflects the negative effect of cachexia and sarcopenia in underweight patients. It does not justify abandoning weight loss goals in obese patients, but it underscores the importance of preserving muscle mass.
  - Unintentional weight loss in patients with advanced heart failure may signal cardiac cachexia and requires evaluation, not encouragement.
  - In patients with diabetes treated with insulin or sulfonylureas, weight loss and increased physical activity increase the risk of hypoglycemia (doses must be adjusted by the treating physician).
- **Conclusion:**

In patients with multivessel disease, visceral obesity sustains low-grade systemic inflammation that accelerates atherosclerosis in all vascular territories. A 5–10% weight loss, achieved through a low-calorie Mediterranean diet, aerobic and resistance training, and behavioral support—supplemented as needed with pharmacological treatment—simultaneously improves blood pressure, the e lipid profile, glycemic control, inflammation, and functional capacity. Maintaining muscle mass must be actively monitored throughout the entire process.

14.6.Antiplatelet and Anticoagulant Therapy—Risks and Special Precautions

Unlike blood pressure control, previously discussed as an ongoing therapeutic goal, antiplatelet and anticoagulant therapy presents a distinct challenge for the rehabilitation team: not the adjustment of a target value, but the management of the associated bleeding risk, which is directly relevant to the safety of physical exercise and to the appropriate course of action in the event of trauma.

- **Dual antiplatelet therapy (DAPT) following acute coronary syndrome**

The standard duration of dual antiplatelet therapy (aspirin plus a P2Y12 inhibitor—clopidogrel, ticagrelor, or prasugrel) following an acute coronary syndrome is 12 months, with individualized adjustments based on the patient's risk of bleeding and residual ischemic risk.

Table 104 . Recommended duration of dual antiplatelet therapy (DAPT) based on risk profile

Risk profile	Recommended duration of DAPT	Note
High bleeding risk (PRECISE-DAPT score ≥ 25)	1–3 months, followed by monotherapy with a P2Y12 inhibitor	Reduces the risk of bleeding while maintaining acceptable ischemic protection
Balanced ischemic-bleeding risk	12 months (standard duration)	The default approach, in the absence of factors justifying shortening or prolonging treatment
High ischemic risk, low bleeding risk	More than 12 months (extension possible)	Individualized decision made by a cardiologist, with periodic reassessment of the benefit-risk ratio

- **Triple therapy in patients indicated for oral anticoagulation**

In patients requiring chronic oral anticoagulation (most commonly for atrial fibrillation) who also an acute coronary event requiring stent implantation, current guidelines recommend limiting the duration of triple therapy (anticoagulant plus dual antiplatelet therapy) to a maximum of one month, followed by dual therapy (anticoagulant plus clopidogrel) for up to approximately 12 months, and subsequently oral anticoagulation monotherapy. This strategy significantly reduces the risk of bleeding without a significant increase in ischemic risk compared with longer periods of triple therapy.

- **Practical Implications for the Rehabilitation Program**
  - Patients on dual antiplatelet therapy or oral anticoagulation are at increased risk of bleeding in the event of trauma; therefore, exercises involving a significant risk of impact or falls should be avoided or approached with extra caution, especially in elderly patients or those with balance disorders;
  - The appearance of extensive bruising, prolonged bleeding following a minor injury, blood in the urine or stool, or an unusually severe headache should be considered warning signs in any patient on antiplatelet or anticoagulant therapy, requiring prompt medical evaluation;
  - The patient's self-initiated discontinuation or omission of antiplatelet/anticoagulant therapy due to minor bleeding or a bruise must be actively discouraged, and any concerns must be referred to the attending physician, not resolved unilaterally by the rehabilitation team.

Practical Note: *The management of bleeding risk associated with antiplatelet/anticoagulant therapy is conceptually different from blood pressure management: it is not about achieving a therapeutic target, but about recognizing and minimizing a risk associated with a treatment that is otherwise necessary and, as a rule, cannot be modified by the rehabilitation team.*

14.7. Erectile Dysfunction as an Early Marker of Systemic Atherosclerosis

The 2026 ESC Guidelines for Cardiac Rehabilitation highlight erectile dysfunction as a relevant early manifestation of systemic atherosclerosis, attributed to the same mechanisms of endothelial dysfunction that underlie coronary and cerebrovascular disease. Because the penile arteries are smaller in caliber than the coronary arteries, erectile dysfunction may precede a major coronary event by months or even years, making it a useful early warning sign, not merely a quality-of-life issue.

The guidelines recommend screening for sexual function in men and women with cardiovascular disease as part of a comprehensive risk assessment, as well as structured sexual counseling as part of the rehabilitation program—both to directly improve sexual function and as an additional, often untapped, opportunity to comprehensively address the patient's cardiovascular risk.

Practical Note: *The inclusion of erectile dysfunction in the discussion of common risk factors is not coincidental: its pathophysiological mechanism is identical to that discussed in Chapter 2, and its presence in a young patient, apparently without other obvious risk factors, may be the first clinical sign of incipient atherosclerotic disease, warranting an active medical history, not merely a discussion initiated by the patient.*

Table 105 . Summary of therapeutic targets in patients with very high-risk/extreme-risk vascular disease

Risk factor	Guideline Target	Primary source
LDL cholesterol (very high risk)	< 55 mg/dl and a reduction of ≥ 50%	ESC/EAS Guidelines for the Management of Dyslipidemia (2025)
LDL cholesterol (extreme risk—2 events in 2 years)	< 40 mg/dl and ≥ 50% reduction	ESC/EAS Guidelines for the Management of Dyslipidemia (2025)
Systolic blood pressure	120–129 mmHg (if tolerated); ALARA in frail/elderly patients	ESC 2024 Guidelines for the Management of Hypertension (2024)
HbA1c	< 7.0%; up to 8.5% in frail patients or those with reduced life expectancy	ESC/EASD Guidelines for the Management of Cardiovascular Disease in Patients with Diabetes (2023)
Antiplatelet/Anticoagulant Therapy	Tailored to ischemic/hemorrhagic risk; avoid unauthorized discontinuation	ESC Guidelines for the Management of Acute Coronary Syndromes (2023)
Smoking status	Complete abstinence	ESC Guidelines for the Prevention of CVD (2019)

Summary: *Risk factor management in patients with vascular disease should be conducted with the same intensity, regardless of the site of the initial clinical event, with strict therapeutic targets, justified by the automatic classification of these patients into the very high or extreme risk category; Screening for sexual dysfunction, explicitly recommended by the 2026 ESC guidelines, provides an additional, simple tool for the early identification of systemic atherosclerotic disease.*

15. PSYCHOLOGICAL AND COGNITIVE ASPECTS

- **The Psychological Impact of Multiple Vascular Events**

Patients who have experienced events in multiple vascular territories, either successively or concurrently, frequently report a greater psychological impact than those with a single isolated event, often experiencing a marked loss of confidence in their own health status—an aspect that must be actively explored during the initial evaluation.

- **Post-Stroke Cognitive Deficits and Their Impact on Adherence**

Cognitive deficits—even mild ones, which are common after a stroke—can affect a patient's ability to retain and apply the recommendations of the rehabilitation program; for this reason, educational materials must be simplified and repeated, and the involvement of a family member often becomes essential, not merely helpful.

- **Post-Stroke Depression**

Depression is common following both myocardial infarction and stroke, with a significant reported prevalence in both populations, and is associated with reduced adherence to treatment and the rehabilitation program; therefore, active screening for depressive symptoms should be systematically included in the assessment of this patient population.

- **Restoring Functional Confidence in Patients with Multiple Events**

Patients who have experienced successive vascular events in different anatomical regions often develop a pronounced fear of the "next event," which can lead to avoidance of physical activity, even in the absence of a real contraindication. Addressing this fear requires a strategy similar to that described for anxiety related to cardiac devices: supervised gradual exposure and, if necessary, specialized psychological support.

- **Family Involvement in the Recovery Process**

For patients with post-stroke cognitive or motor deficits, as well as for patients who have experienced multiple cerebrovascular events, the active involvement of a family member in educational discussions and, when possible, in exercise sessions, significantly contributes to adherence and the early recognition of any deterioration at home.

Summary: *The psychological and cognitive impact of cerebrovascular disease—particularly when it affects multiple areas or is associated with a stroke—is an essential, not optional, component of the assessment and rehabilitation plan, with direct implications for adherence and, ultimately, for long-term outcomes.*

16. PRACTICAL ORGANIZATION IN THE REHABILITATION UNIT

- **Interdisciplinary Collaboration**

Optimal management of a patient with vascular disease frequently requires collaboration among a cardiologist, neurologist, vascular surgeon, and physical therapist—a collaboration that is more extensive than that encountered in "classic" cardiovascular rehabilitation—and the student must understand and respect the limits of each specialty's expertise.

Practical Note: *When a patient presents signs or symptoms from a vascular territory different from that of the primary diagnosis, this must be immediately reported to the coordinating team, rather than assuming it is irrelevant to the ongoing rehabilitation program.*

- **Targeted Competencies**
    - conducting a comprehensive initial assessment that actively covers all three vascular territories;
    - correctly interpreting the ankle-brachial index and exercise testing results in patients with multivascular disease;
    - adapting the exercise prescription to the coexistence of multiple vascular conditions;
    - recognizing warning signs specific to each territory and applying the appropriate management strategy;
    - effective communication with an expanded interdisciplinary team (cardiologist, neurologist, vascular surgeon).

- **Guideline for Organizing the Medical Record of a Patient with Vascular Disease**

It is recommended that a patient's vascular disease record be structured into sections corresponding to the three domains, with an additional section explicitly dedicated to common risk factors and overall therapeutic goals, facilitating rapid consultation by any team member, regardless of their specialty.

17. WORKSHEETS

Table106 . Initial Assessment Form for Patients with Vascular Disease

Section	Items to be completed
Coronary territory	Diagnosis, type of revascularization, stress test results
Cerebral territory	History of stroke/TIA, residual deficits, disability scale
Peripheral territory	History of claudication, ankle-brachial index, peripheral revascularization
Risk factors	Lipid profile, blood pressure, smoking status, diabetes
Current treatment	Antiplatelet/anticoagulant, lipid-lowering agents, other relevant classes
Psychological/cognitive status	Screening for depression, relevant cognitive deficits

- **Session Monitoring Form**

In addition to standard parameters, the monitoring form must include a section dedicated to checking for warning signs in all three domains, to be completed at every session, not just during the initial assessment.

Table107 . Screening form for polyvascular disease

Screening Item	Result
Bilateral carotid pulse, present/murmur	___
Bilateral femoral, popliteal, and pedal pulses	___
Ankle-brachial index (if indicated)	___
History of TIA/stroke	___
History of claudication	___
Decision: Requires further evaluation (Yes/No)	___

Practical Note: *This simple screening form should be completed during the initial evaluation of any patient enrolled in the program for a coronary event, regardless of whether or not the patient spontaneously reports symptoms in other areas.*

18. CASE STUDIES

Case 1

A 64-year-old patient, 4 weeks post-myocardial infarction treated with PCI, with a 2-year history of intermittent claudication that had not been actively treated until now, and an ankle-brachial index of 0.65 in the right lower limb.

Requirements:

1. Classify this patient as having polyvascular disease, justifying your answer.
2. Propose a treatment plan that integrates both post-PCI recovery and supervised walking therapy for peripheral arterial disease (PAD).
3. Specify the enhanced objectives for risk factor control, given the polyvascular involvement.

Case 2

A 70-year-old female patient, 6 weeks after a minor ischemic stroke, with mild residual motor deficit in the left upper limb and no known coronary artery disease. On examination, an asymptomatic right carotid bruit is detected.

Requirements:

1. Specify the appropriate management following the detection of a carotid murmur.
2. Propose a program structure that integrates neuromotor rehabilitation with cardiovascular components.
3. List the specific warning signs that the team must actively monitor.

Practical Note: *Both cases illustrate the central principle of this manual: the assessment and management of patients with vascular disease must go beyond the seemingly "primary" territory, actively integrating the risk and, when necessary, the treatment of involvement in other vascular territories.*

Case 3

A 68-year-old patient with Fontaine stage IIb peripheral arterial disease, treated with superficial femoral angioplasty 2 months ago, an active smoker, with an LDL cholesterol level of 145 mg/dl despite treatment with a moderate dose of statins. He has no reported cardiac or neurological symptoms, but has never been actively evaluated for them.

Requirements:

1. Propose screening criteria for asymptomatic polyvascular disease in this patient.
2. Discuss whether the current lipid-lowering therapy is appropriate for this patient's risk category.
3. Develop a rehabilitation program that combines supervised walking after revascularization with smoking cessation intervention.

Practical Note: *This third case illustrates a common scenario: a patient actively treated for a single (peripheral) site, with inadequately controlled risk factors and no assessment of the other sites—exactly the type of patient who should be actively identified through the screening discussed in Chapter 6.*

Case 4

A 75-year-old female patient with a history of myocardial infarction 8 years ago (without structured rehabilitation at the time) and a minor ischemic stroke 3 years ago; she currently has a Rankin score of 1, with no known pulmonary hypertension, but has never been evaluated using the ankle-brachial index. She is now being referred to rehabilitation for a recent episode of decompensated heart failure.

Requirements:

1. Discuss the relevance of the patient's past history of myocardial infarction and stroke to her current evaluation.
2. Propose ways to complete the evaluation by adding the missing screening elements.
3. Outline the program's objectives, taking into account her age, multiple medical history, and current event.

Practical Note: *This latest case illustrates that polyvascular disease is not always evident at first glance: a patient with a history of vascular events in different vascular territories, but occurring a long time apart, can easily be "compartmentalized" by the healthcare system, even though she would benefit—perhaps more than any of the previous cases—from an integrated, unified approach.*

GUIDELINES FOR RESOLVING CASE STUDIES

- **Case 1**
  - Confirmed polyvascular disease: documented coronary artery disease (recent myocardial infarction) + documented peripheral arterial disease (claudication, ankle-brachial index 0.65);
  - Program structure: supervised walking for PAD, at an intensity that respects the coronary threshold identified by post-PCI exercise testing;
  - Intensified goals: strict LDL-cholesterol target (very high-risk category), rigorous blood pressure control, smoking cessation counseling, if applicable.

- **Case 2**
  - Management of carotid bruit: referral for carotid Doppler ultrasound, additional vascular/neurological evaluation;
  - Program structure: coordination with the neuromotor rehabilitation team, exercises tailored to upper limb deficits, aerobic component based on tolerance;
  - Signs to monitor: new or worsening neurological deficit, cardiac signs, peripheral vascular signs
- **Case 3**
  - Possible, unevaluated polyvascular involvement: documented PAD (Fontaine IIb, post-superficial femoral angioplasty); the absence of cardiac symptoms does not rule out coronary artery disease, as claudication limits exertion before ischemia occurs; active screening includes ECG, echocardiography, exercise testing on a cycle ergometer, carotid Doppler ultrasound, and abdominal ultrasound for aortic aneurysm;
  - Inadequate lipid-lowering therapy: the risk category is very high, with an LDL-cholesterol target below 55 mg/dL (compared to the current level of 145 mg/dL; high-intensity statins and ezetimibe are required, followed by a PCSK9 inhibitor if the target is not met);
  - rehabilitation program structure: supervised post-revascularization walking on a treadmill, 3 times a week, for a minimum of 12 weeks, up to moderate to severe claudication (heart rate is maintained below the safety threshold established during the exercise test);
  - smoking cessation as a priority intervention: structured counseling and pharmacological treatment, integrated into every session (continued smoking increases the risk of restenosis, occlusion, and amputation).
- **Case 4**
  - Relevance of medical history: Myocardial infarction and stroke confirm polyvascular disease, thus indicating very high risk, regardless of time elapsed. A previous myocardial infarction suggests an ischemic etiology for the current heart failure;
  - Screening to be completed: ABI, carotid Doppler ultrasound, echocardiography, Holter ECG for AF, lipid profile (LDL-cholesterol target below 55 mg/dl), assessment of frailty and cognitive function;
  - Rehabilitation program structure: enrollment only after clinical stabilization, with low initial intensity and slow progression. Balance exercises are added due to the risk of falls;
  - Objectives: prevention of readmissions through education on self-monitoring of heart failure, maintenance of functional independence, and strict blood pressure and lipid control.

19. TELEREHABILITATION FOR PATIENTS WITH VASCULAR DISEASE

- **The Applicability of Telerehabilitation Across the Three Areas**

Telerehabilitation, discussed at length in materials dedicated to complex cases, has varying applicability across the three areas: well-documented and accepted in traditional cardiac rehabilitation, currently expanding for patients with PAD (through at-home walking programs monitored remotely), and more limited in post-stroke patients with significant cognitive or communication deficits, which may limit their ability to follow a program without direct supervision.

- **Selection criteria for vascular patients for telerehabilitation**
  - documented clinical stability in all affected areas, not just the "primary" one;
  - the absence of cognitive or communication impairments that would limit the ability to understand safety instructions;
  - access to the necessary technology and the ability to use it, possibly with the support of a family member.

Practical note: *For patients with multivascular involvement, the decision to recommend telerehabilitation must take into account the most restrictive of the criteria imposed by each affected territory, not just those of the territory with the most favorable outcome.*

- **Psychosocial Interventions via Digital Health (ESC 2026 Guidelines)**

The ESC 2026 Guidelines for Cardiac Rehabilitation highlight the increasingly important role of digital health interventions for the psychosocial component of the program, noting their advantage of providing easy, at low cost, to a wide range of interventions, tailored to each patient's preferences and delivered by rehabilitation staff (e.g., nurses trained for this purpose).

For patients with vascular disease, who face specific barriers to access—such as residual motor deficits following a stroke, limited walking distance in the PAD, and mobility difficulties in older adults with multiple comorbidities— these digital solutions can serve as a valuable alternative for maintaining long-term psychosocial support, complementing the home exercise program discussed in the previous sections of this chapter.

Summary: *Telerehabilitation is a valuable, complementary tool for tracking the progress of patients with polyvascular disease in relation to their recovery program, especially in Phase III, and its extension to digital health psychosocial interventions—explicitly supported by the 2026 ESC guidelines—offers an additional solution for patients with specific access barriers, without replacing direct clinical assessment when it is necessary.*

Appendix 1. Expanded Initial Assessment Form for the Multivascular Patient

Table 108 . Expanded Initial Assessment Form for Multivascular Patients

Section	Items to be completed
General Information	Age, sex, primary diagnosis, date of event/procedure
Coronary Territory	Diagnosis, type of revascularization, stress test result, residual ischemia (Yes/No)
Cerebral territory	History of stroke/TIA, type (atherothrombotic/cardioembolic/other), Rankin score, residual deficits
Peripheral territory	History of claudication, ankle-brachial index, Fontaine stage, peripheral revascularization
Multivessel screening	Results from the worksheet in Chapter 16.3
Risk factors	Lipid profile, blood pressure, HbA1c (if diabetic), smoking status
Current treatment	Antiplatelet/anticoagulant, lipid-lowering, other relevant classes
Nutritional status	BMI, dysphagia assessment (if stroke), adherence to recommended dietary guidelines
Psychological/cognitive status	Depression screening, relevant cognitive deficits
Individual goals	Functional goals discussed and agreed upon with the patient

Appendix 2. Guideline for Emergency Care of Patients with Cerebrovascular Disease

The protocol below must be adapted to the resources of each department and made known to all staff involved in training sessions.

1. Immediately cease all activities at the first warning sign in any of the three areas;
2. Place the patient in a safe position and rapidly assess vital signs and neurological status (if relevant);
3. Identify the likely affected area (cardiac, neurological, or peripheral vascular) based on the predominant symptoms;
4. Activate the appropriate emergency protocol (cardiac team, neurological emergency team, or vascular team, as appropriate);
5. Thoroughly document the event immediately after stabilization.

Practical Note: *An in-hospital "stroke code," when available, must be activated immediately upon any suspicion of a new-onset neurological deficit, regardless of the primary diagnosis of the patient participating in the simulation exercise.*

Appendix 3. Sample Completed Multivascular Screening Form

The example below, based on Case 3, illustrates how to complete the worksheet.

Table 109 . Example of a completed multivascular screening form

Screening Item	Example Result
Bilateral carotid pulse, present/murmur	Present bilaterally, no audible murmur
Bilateral femoral, popliteal, and pedal pulses	Diminished in the left lower limb, treated with angioplasty
Ankle-brachial index	0.55 on the left (post-revascularization, improving), 0.95 on the right
History of TIA/stroke	None; not previously evaluated
History of claudication	Present, Fontaine stage IIb
Decision: requires further evaluation	Yes—complete cardiological evaluation, given the uncontrolled risk profile

ABBREVIATIONS

110 . Glossary of Abbreviations – Chapter IV

Abbreviation	Meaning
ACC	American College of Cardiology
ACS	Acute coronary syndrome (unstable angina, STEMI, NSTEMI)
AHA	American Heart Association
ALARA	As Low As Reasonably Achievable – a principle for individualizing blood pressure targets in the elderly and frail
BMI	Body Mass Index
CABG	Coronary Artery Bypass Grafting – aortocoronary bypass
CAD	Coronary artery disease
CCS	Chronic coronary syndrome
DAPT	Dual Antiplatelet Therapy – dual antiplatelet therapy (aspirin + P2Y12 inhibitor)
EAS	European Atherosclerosis Society – co-author of the European guidelines on dyslipidemia
EASD	European Association for the Study of Diabetes – the leading European society in diabetology
ESC	European Society of Cardiology – the primary source of the guidelines cited in this manual
ESVS	European Society for Vascular Surgery – the European Society for Vascular Surgery
FITT	Frequency, Intensity, Time, Type – a principle for structuring exercise prescriptions
GLP-1 RA	Glucagon-like peptide-1 receptor agonist
HbA1c	Glycated hemoglobin, a marker of medium-term glycemic control
HDL	High-Density Lipoprotein – high-density lipoprotein (“good” cholesterol)
LDL	Low-Density Lipoprotein – low-density lipoprotein, the primary target of lipid-lowering therapy
MTF/MTHR	Maximum Tolerated Frequency/Maximum Tolerated Heart Rate
NIHSS	National Institutes of Health Stroke Scale – a scale for assessing stroke severity
NSTEMI	Non-ST-Elevation Myocardial Infarction – myocardial infarction without ST-segment elevation
PAD	Peripheral Arterial Disease
PCI	Percutaneous Coronary Intervention
PCSK9	Proprotein Convertase Subtilisin/Kexin type 9 – therapeutic target for next-generation lipid-lowering inhibitors
PRECISE-DAPT	Score for estimating bleeding risk in patients on dual antiplatelet therapy

Abbreviation	Meaning
SGLT2	Sodium-Glucose Cotransporter 2 – a target for a class of antidiabetic drugs with proven cardiovascular benefits
SPPB	Short Physical Performance Battery – a battery of tests for assessing physical performance
STEMI	ST-Elevation Myocardial Infarction – myocardial infarction with ST-segment elevation
Stroke	Cerebrovascular accident
TIA	Transient ischemic attack
TUG	Timed Up and Go – a test of functional mobility and fall risk
VO2 (peak)	Maximum oxygen consumption achieved during exercise, a key parameter in cardiopulmonary testing

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CHAPTER V. RECOVERY OF PATIENTS WITH HEART FAILURE

Laura Crăciun

1. INTRODUCTION

- **Heart Failure as a Complex Clinical Syndrome**

Heart failure (HF) is not a single disease, but a complex clinical syndrome defined by the presence of symptoms and/or signs (dyspnea, fatigue, edema) caused by a structural and/or functional cardiac abnormality, which leads to increased intracardiac pressures and/or a cardiac output inadequate for the body's metabolic needs, at rest or during exertion.
The prevalence of HF is estimated at 1–3% of the general adult population, and despite significant improvements in mortality over the past three decades, fewer than 60% of diagnosed patients survive in the long term, underscoring the ongoing need to optimize management, including through structured cardiovascular rehabilitation.

- **The Role of Cardiovascular Rehabilitation in the Modern Management of Heart Failure**

Structured physical training, integrated into a comprehensive cardiovascular rehabilitation program, is now a therapeutic component in its own right of heart failure management, not an adjunctive or optional measure. Far from being contraindicated in a patient with a "weak heart," physical exercise acts on peripheral pathophysiological mechanisms such as skeletal muscle dysfunction and endothelial function, which are just as relevant to symptoms as central cardiac dysfunction.

- **Benefits on Functional Capacity**

The most consistent and well-documented benefit of physical training in patients with HF is improved exercise capacity, as measured by an increase in peak VO_2 (the maximum amount of oxygen the body consumes during intense physical exertion) and the distance covered on the 6-minute walk test (*6-Minute Walk Test*, abbreviated as **6MWT).** This improvement occurs through both **central** mechanisms (partial reverse remodeling in some patients) and **peripheral** mechanisms, including improvements in muscle capillary density, mitochondrial function, and endothelial function; the latter explain why functional benefits often appear before any measurable changes in ejection fraction.

- **Benefits to Quality of Life and Symptomatology**

Improved exercise tolerance directly translates into a reduction in limiting symptoms (dyspnea, fatigue) at a given activity level, with a consistently documented impact on patient-reported quality of life, as measured by specific questionnaires such as **the KCCQ —the Kansas City Cardiomyopathy Questionnaire** (assesses functional status and quality of life specific to heart failure: physical limitations, symptoms—frequency, severity, recent changes)—or **the MLHFQ—the Minnesota Living with Heart Failure Questionnaire** (assesses the disease's impact across three dimensions: physical, emotional, and socioeconomic).

- **Benefits on Hospitalization Rates**

The largest randomized trial on this topic, HF-ACTION, included over 2,300 patients with HFrEF (mean ejection fraction of 25%), randomized to an aerobic exercise program or standard care. The primary outcome (mortality or hospitalization from any cause) did not reach statistical significance in the unadjusted analysis; but, after adjusting for important prognostic factors (etiology of HF, ejection fraction, depressive symptoms), exercise was associated with a significant reduction of approximately 11% in the adjusted risk of all-cause mortality or hospitalization, and approximately 15% in the risk of cardiovascular mortality or hospitalization for HF.

- **Practical Note:** *The HF-ACTION results illustrate an important observation: the benefit of exercise on "hard" outcomes (mortality, hospitalization) may be less evident in crude*

analyses than that on functional capacity and quality of life, largely due to variable adherence to the prescribed program over the long term—a further argument for the importance of adherence-maintenance strategies

Subsequent data from dose-response analyses of the same study suggest that each increase in the volume of exercise actually performed is associated with a further reduction in risk; this relationship is not linear but diminishes beyond a certain threshold—an observation that supports the recommendation for a "sufficient but realistic" volume of exercise, rather than maximizing intensity at any cost.

- **Benefits on Risk Factors and Metabolic Profile**

Beyond its direct effects on exercise capacity, regular physical training helps improve the patient's overall metabolic profile—glycemic control, lipid profile, and weight control—which is particularly relevant for patients with HF and associated metabolic comorbidities, discussed in detail in Chapter 4, thereby complementing the effect of pharmacological therapy without replacing it.

- **Psychological and Social Benefits**

Participation in a structured exercise program—often conducted in a group setting under supervision—also offers benefits that are less objectively quantifiable but clinically relevant: a reduction in anxiety and depressive symptoms, which are common in patients with HF, an increase in the patient's confidence in their own physical abilities, and support for social reintegration, which is often impaired by the fear of exertion experienced following a diagnosis of heart failure.

- **Summary:** *The benefits of cardiovascular rehabilitation for patients with HF span a broad spectrum—functional capacity, quality of life, hospitalization rates, metabolic profile, and psychological well-being—supported by the largest randomized trial in the field (HF-ACTION), which demonstrates a robust benefit on functional capacity and quality of life.*

- **Objectives**
  - to explain the central and peripheral pathophysiological mechanisms of heart failure;
  - the practical implications of the cardiovascular rehabilitation program through the application of the updated classification of heart failure—HFrEF (Heart Failure with reduced Ejection Fraction) and HFpEF (Heart Failure with preserved Ejection Fraction), according to the 2026 ESC Guidelines for the Management of Heart Failure;
  - recognition of common comorbidities and their impact on the exercise program;
  - conducting a comprehensive initial assessment, including risk stratification prior to program enrollment;
  - tailoring the cardiovascular rehabilitation program to patients with HFrEF, HFpEF, or those who have undergone cardiac surgery;
  - monitoring the patient and recognizing signs of decompensation throughout the program.

- **Epidemiological Highlights**

Heart failure remains a major cause of morbidity and mortality worldwide, with an increasing incidence attributed to both an aging population and increased survival among patients with acute coronary syndrome, many of whom subsequently develop chronic ventricular dysfunction. The costs associated with heart failure, largely driven by repeated hospitalizations for decompensation, make the prevention of these episodes a central goal of any therapeutic intervention, including structured cardiovascular rehabilitation.

2. PATHOPHYSIOLOGY OF HEART FAILURE AND VENTRICULAR REMODELING

- **Mechanisms of Ventricular Remodeling**

Ventricular remodeling refers to the progressive structural changes (size, shape, wall thickness) that the left ventricle undergoes in response to chronic pressure or volume overload, or to a loss of contractile mass (e.g., post-infarction). Eccentric remodeling, with ventricular dilation, is typical of HFrEF, whereas concentric remodeling, with wall hypertrophy and a normal or reduced cavity, is typical of HFpEF.

- **Neurohormonal activation and the vicious cycle of progression**

Decreased pumping performance activates the sympathetic nervous system and the renin-angiotensin-aldosterone system through a compensatory mechanism initially intended to maintain organ perfusion. However, chronic, sustained activation of these systems has adverse effects such as excessive vasoconstriction, fluid and salt retention, and accelerated myocardial remodeling, contributing to a vicious cycle that underlies both modern pharmacological treatment of HF and some of the benefits of physical exercise, which helps rebalance this neurohormonal tone.

- **Peripheral Mechanisms—Skeletal Muscle Dysfunction**

A significant portion of the exercise intolerance reported by patients with HF is not explained solely by central cardiac dysfunction, but by peripheral changes such as reduced muscle capillary density, a decrease in the proportion of oxidative fibers, and mitochondrial and endothelial dysfunction, which independently contribute to limiting exercise capacity. This observation underscores the central role of physical training in recovery: a significant portion of the functional benefit occurs at the peripheral level, not merely through the improvement of central cardiac function.

- **Ventricular Interdependence and the Role of the Right Ventricle**

Although HF is often discussed from the perspective of the left ventricle, right ventricular dysfunction—whether secondary to chronic pulmonary hypertension or primary right ventricular disease—significantly contributes to symptoms and exercise limitation due to the mechanical interdependence between the two ventricles, which are separated by the interventricular septum and surrounded by the pericardium. Assessment of right ventricular function, which is often underestimated in routine practice, is essential for a complete understanding of functional limitations in some patients.

- **Congestion as an Active Process of Blood Volume Redistribution**

Congestion, the result of increased cardiac filling pressures, is not merely a local pulmonary or systemic phenomenon, but an active process involving the redistribution of blood volume from the splanchnic venous bed to the central circulation, mediated by sympathetic activation. This modern understanding of congestion explains why some patients develop symptoms of decompensation without a proportional weight gain—a phenomenon relevant to the monitoring of patients with heart failure enrolled in a cardiovascular rehabilitation program.

Summary: *Heart failure involves ventricular remodeling (eccentric in HFrEF, concentric in HFpEF), chronic neurohormonal activation with adverse long-term effects, significant peripheral skeletal muscle dysfunction, and, in some patients, significant right-to-left ventricular interdependence—mechanisms that, together, explain why exercise is a core therapeutic intervention, not merely an adjunct.*

3. CLASSIFICATION AND STAGING OF HF—PRACTICAL IMPLICATIONS FOR CARDIOVASCULAR REHABILITATION

3.1. The Updated Definition of HF According to the 2026 ESC Guidelines

The latest ESC Guidelines on the Management of Heart Failure from 2026, presented at the Munich Congress (August 28, 2026) and replacing the 2021 edition, introduce a major change in classification: the category of heart failure with mildly reduced ejection fraction (HFmrEF, EF 41–49%), introduced in 2021, has been eliminated. Only **two phenotypes** remain, defined by a single ejection fraction (EF) threshold set at 50%: heart failure with reduced ejection fraction (HFrEF), now defined as an EF below 50% (compared to the previous threshold of ≤40%), and heart failure with preserved ejection fraction (HFpEF), defined as an EF of 50% or higher—a definition unchanged from 2021.

Table 111 . Definition of heart failure—the 2021 ESC guidelines versus the 2026 ESC guidelines

Aspect	**2021 ESC Guidelines (previous)**	**2026 ESC Guidelines (current)**
Phenotypes by EF	Three categories: HFrEF (EF ≤40%), HFmrEF (EF 41–49%), HFpEF (EF ≥50%)	Two categories: HFrEF (EF <50%), HFpEF (EF ≥50%)
Terminology for the acute form	"Acute" heart failure	"Decompensated" heart failure
Drug therapy	Optimal medical therapy (GDMT), without explicit subclassification	GDMT consisting of fundamental therapy (FMT) and adjunctive therapy (AMT), plus guided interventional therapy (GDIT)

Practical note: *Reason for removing HFmrEF: accumulated data show that patients with an EF of 41–49% have a pathophysiology and therapeutic response similar to those with classic HFrEF. An EF value of 45%, for example, should no longer be interpreted as "mild heart failure," but rather classified directly as HFrEF, with all the associated therapeutic implications.*

- **Diagnostic Challenges in HFpEF**

In practice, the diagnosis of HFpEF remains more difficult than that of HFrEF, since a normal ejection fraction does not rule out the presence of significant diastolic dysfunction; structured diagnostic algorithms, which integrate clinical parameters, echocardiographic findings (diastolic function, atrial dimensions), and natriuretic biomarkers, are recommended for confirming the diagnosis in patients with suggestive symptoms but a preserved ejection fraction.

- **Definition of HFpEF—the three necessary conditions**

Beyond the workflow algorithm detailed below, the diagnosis of HFpEF is established, specifically, by the simultaneous fulfillment of three conditions:

Table 112 . Definition of HFpEF – the three necessary conditions

Condition	What this means, specifically
1. Symptoms and/or signs of heart failure	Dyspnea, fatigue, edema, rales, jugular vein distension
2. Preserved ejection fraction (EF)	LVEF ≥50%, measured by echocardiography (Simpson biplane method)
3. Objective evidence of structural and/or functional cardiac abnormalities consistent with elevated left ventricular filling pressures	• Elevated NT-proBNP above 125 pg/mL in sinus rhythm/above 365 pg/mL in patients with atrial fibrillation • structural changes: left atrial (LA) dilation and left ventricular (LV) hypertrophy; • direct evidence of elevated LV filling pressures on echocardiography (elevated E/e' ratio/other Doppler parameters of diastolic function), or, when echocardiography is inconclusive, through direct invasive measurement (right heart catheterization, with elevated blocked pulmonary capillary pressure at rest or during exercise).

Practical note: *It is important to note that: an isolated EF ≥50% is NOT sufficient for a diagnosis of HFpEF—additionally, symptoms/signs of heart failure AND objective evidence of elevated filling pressures (biological, via NT-proBNP; structural, via LA dilation; or direct hemodynamic) are required. The absence of this third condition most likely means that the patient's dyspnea has a cause other than heart failure.*

- **Practical Implications of Recovery: HFrEF versus HFpEF**
  - the dominant mechanism of functional limitation: in **HFrEF**, central systolic dysfunction, along with peripheral dysfunction common to both phenotypes; in **HFpEF**, diastolic stiffening, frequently associated with a pattern of multimorbidity (obesity, hypertension, atrial fibrillation, diabetes), which often determines actual exercise tolerance more than isolated cardiac dysfunction;
  - Intensity dosing benchmark: in **HFrEF**, the ventilatory threshold obtained through cardiopulmonary exercise testing remains the preferred benchmark, especially in patients on beta-blockers, in whom the chronotropic response is reduced; in **HFpEF**, blood pressure control and ventricular rate in AF (if present) may become limiting factors just as relevant as the ventilatory threshold;
  - the magnitude and mechanism of the expected benefit: in **HFrEF**, part of the benefit may include partial reverse remodeling, along with peripheral improvement; in **HFpEF**, the benefit is attributed almost exclusively to peripheral mechanisms and the management of comorbidities, with no consistent evidence of exercise-induced structural cardiac remodeling;
  - specific risks to monitor: in **HFrEF**, a higher risk of arrhythmias and the need for coordination with cardiac devices (*CRT—Cardiac Resynchronization Therapy* / ICD—*Implantable Cardioverter-Defibrillator*), when present; in **HFpEF**, a higher risk of an exaggerated hypertensive response to exercise and of decompensation related to difficult volume control in patients with multiple cardiovascular comorbidities;
  - the role of concomitant pharmacological therapy: in **HFrEF**, optimal comprehensive medical therapy (beta-blocker, ARNI/ACE inhibitor — *Angiotensin Receptor–Neprilysin Inhibitor/ACE inhibitors*, MRAs — *Mineralocorticoid Receptor Antagonists*, SGLT2i — *Sodium-Glucose Cotransporter 2 inhibitors*) directly influences the response to exercise; in **HFpEF**, *Foundational Medical Therapy* (FMT) is more limited (MRAs, SGLT2i), and GIP/GLP-1 agonists, when obesity is present, may become relevant to the program's outcome.

Practical Note: *Although the general safety principles (individualized safety threshold, active monitoring, gradual progression) remain the same, the "standard" exercise prescription cannot be automatically transferred from HFrEF to HFpEF: in the first phenotype, the rehabilitation team primarily manages a weakened heart; in the latter, it manages, often in equal measure, a stiff heart and a patient with multiple concurrent comorbidities.*

3.2. Staging of HF According to the 2026 ESC Guidelines on the Management of HF

Complementing the phenotype-based classification, the 2026 ESC Guidelines adopt a stage-based approach, from A to D, with an explicit focus on prevention and early disease detection, reflecting the continuous spectrum from the risk of developing HF to advanced disease.

Table 113 . Staging of heart failure according to the 2026 ESC Guidelines

Stage	Description
A	Risk of developing heart failure (risk factors present), without structural disease or symptoms
B	Structural heart disease present (e.g., asymptomatic ventricular dysfunction), without symptoms of heart failure
C	Structural heart disease associated with current or past symptoms of heart failure
D	Advanced heart failure, refractory to standard treatment

This staging complements, but does not replace, the NYHA functional class (I–IV), which continues to be used to describe the functional limitation of symptomatic patients (stages C–D) and to guide the intensity of exercise in the cardiovascular rehabilitation program.

- **Decompensated versus stable chronic heart failure—relevance to rehabilitation**

The renaming of the "acute" form to "decompensated" reflects the recognition that the deterioration of cardiac function can be gradual, not necessarily sudden—a patient may gradually progress toward decompensation without a single identifiable precipitating event. For the rehabilitation team, the essential distinction remains practical: an actively decompensated patient is not a candidate for supervised exercise, regardless of the mechanism (sudden or gradual) by which they reached this state, and inclusion in the program must be postponed until documented clinical stabilization.

- **Strong recommendations for practice in the cardiovascular rehabilitation unit**
  - Early recognition of gradual decompensation: since deterioration can be slow, the rehabilitation team—which sees the patient repeatedly at short intervals—is often best positioned to observe the first early signs (progressive weight gain, gradual decrease in exercise tolerance from one session to the next) before overt decompensation occurs;
  - the timing of resuming the program after decompensation: documented clinical stabilization (not merely subjective improvement) must be confirmed by the attending physician before resuming exercise, and reentry into the program is typically achieved through a comprehensive reassessment, not simply by continuing where the program was interrupted;
  - a more conservative progression upon resumption: even in a patient who has returned to the same apparent functional stage, the intensity of exercise upon resumption must be more cautious than it was before decompensation, with a new period of gradual progression, rather than a direct return to the last tolerated intensity;
  - the distinction between "unstable" and "severe but stable": a patient with advanced HF (stage D) who has been clinically stable for several weeks remains a candidate for an adapted program, unlike a patient with less severe HF who is currently decompensated—the severity of the underlying disease and current stability are distinct, not interchangeable, criteria for the decision to include a patient.

Summary: *The current classification of HF distinguishes only between HFrEF (EF <50%) and HFpEF (EF ≥50%), supplemented by a prevention-oriented A–D staging system; the term "decompensated" replaces "acute," but the practical principle for recovery remains unchanged: clinical stability, not the terminological label, determines the timing of inclusion in the program.*

3.3. NYHA (New York Heart Association) Functional Classification

The name comes from the New York Heart Association, the American medical society that developed this functional classification system in 1928, which has since become the most widely used tool worldwide for describing the symptomatic severity of heart failure.

Table 114 . NYHA Functional Classification

NYHA Class	Description
I	No limitation on usual physical activity
II	Mild limitation, symptoms with routine exertion
III	Marked limitation, symptoms with minimal exertion
IV	Symptoms at rest, worsened by any activity

- **Practical utility of the NYHA classification**
  - simplicity and speed—it is determined solely from the medical history, without equipment, in a few minutes, unlike cardiopulmonary exercise testing;
  - common language across specialties—cardiologists, primary care physicians, and physical therapists immediately understand the patient's functional severity without ambiguity;
  - initial guidance on exercise intensity — a practical starting point for prescribing exercise before exercise test results are available;
  - prognostic value—more advanced classes (III–IV) are associated with an increased risk of hospitalization and mortality;
  - Simple longitudinal monitoring—a change in class (e.g., from II to III) quickly signals a possible worsening of the condition, which is useful for the rehabilitation team at each visit.

Practical note: *The major limitation of the NYHA classification: since it is based on the patient's subjective report rather than an objective measurement, it is less accurate than cardiopulmonary exercise testing; for this reason, it should be supplemented with exercise testing whenever possible and not used in isolation for detailed clinical decisions.*

Conclusion: The NYHA class remains the most widely used practical guideline for the initial determination of exercise intensity, although it should be supplemented, whenever possible, with objective cardiopulmonary exercise testing.

4. COMMON COMORBIDITIES IN PATIENTS WITH HF

- **Chronic Kidney Disease and Cardiorenal Syndrome**

Chronic kidney disease is present in a substantial proportion of patients with HF, and the bidirectional interaction between the two organs (cardiorenal syndrome) complicates both volume management and the selection and dosing of pharmacological therapy, with direct implications for exercise tolerance and the risk of complications during exercise.

- **Diabetes Mellitus and Heart Failure**

Diabetes mellitus frequently coexists with HF and is associated with a poorer prognosis compared to patients without diabetes; SGLT2 inhibitors, discussed in Chapter 10, represent a therapeutic class with dual cardiovascular and metabolic benefits for this patient population.

- **Associated atrial fibrillation**

Atrial fibrillation, which is frequently associated with HF, complicates exercise prescribing due to the need to monitor ventricular rate during exercise—not just at rest—and due to the bleeding risk associated with oral anticoagulation, when indicated.

- **COPD, anemia, and iron deficiency**

Chronic obstructive pulmonary disease can mask or exacerbate exertional dyspnea, complicating the interpretation of symptoms. Anemia and, independently of it, iron deficiency (even in the absence of overt anemia) are common in patients with heart failure and contribute to limited exercise capacity; for this reason, active screening for iron deficiency is routinely recommended.

Practical Note: *Systematic screening for the comorbidities listed above should be part of the initial evaluation of any patient with heart failure enrolled in a rehabilitation program, as each of these conditions can limit the patient's actual exercise capacity, regardless of the severity of cardiac dysfunction.*

- **Frailty in Older Adults with Heart Failure**

Frailty, a syndrome characterized by a reduction in overall physiological reserve, is common in older patients with heart failure and increases the risk of hospitalization and exercise-related complications; for this reason, its assessment (e.g., using the Clinical Frailty Scale) should be included in the initial assessment of older patients, alongside the classic comorbidities discussed earlier.

Table 115 . Summary of the impact of comorbidities on physical activity prescriptions

Comorbidity	Impact on physical activity prescription
Chronic kidney disease	Pay attention to fluid management; for dialysis patients, synchronize with dialysis sessions
Diabetes	Check blood glucose levels before exercise; risk of hypoglycemia with insulin/sulfonylurea therapy
Atrial fibrillation	Check heart rate control during exercise, not just at rest
COPD	Differentiating cardiac dyspnea from pulmonary dyspnea; possible additional ventilatory limitation
Anemia/iron deficiency	Limited oxygen-carrying capacity, regardless of cardiac status
Frailty	Slower progression, emphasis on strength and balance exercises

- **Depression and anxiety as comorbidities**

From a psychological perspective, depression and anxiety must also be recognized here as genuine comorbidities of HF, with a documented impact on prognosis—not just on quality of life—which is why screening for them should be systematically included alongside the somatic comorbidities listed above.

5. INITIAL EVALUATION OF THE PATIENT WITH HF

- **Medical History and Physical Examination**

The medical history must explicitly document the history of decompensation episodes, the current NYHA functional class, current treatment, and adherence to it, and the clinical examination must actively look for signs of congestion (rales, edema, jugular vein distension, hepatomegaly) and signs of reduced cardiac output (cold extremities, prolonged capillary refill time).

Table 116 . Minimum laboratory and diagnostic workup for patients with heart failure

Category	Recommended Minimum Tests	Primary Relevance
Biomarkers	NT-proBNP or BNP	Diagnostic confirmation, correlation with severity, longitudinal monitoring
General laboratory workup	Renal function, electrolytes, complete blood count, iron status (ferritin, transferrin saturation), glycemic profile	Screening for comorbidities discussed in Chapter 4
Electrocardiogram	12-lead ECG	Baseline rhythm, signs of necrosis/ischemia, conduction disturbances
Transthoracic Echocardiography	Ejection fraction, ventricular dimensions and volumes, diastolic assessment, associated valvular diseases	Required for classification as HFrEF/HFpEF

- **Exercise testing**
  - **Cardiopulmonary exercise testing (CPET)** with direct measurement of gas exchange is **the test of choice** for assessing functional capacity in patients with heart failure; it is superior to the standard test for determining the ventilatory threshold, which is the preferred benchmark for prescribing exercise. Parameters such as peak VO_2 *(**maximum oxygen consumption reached during the exercise test**)* and the VE/VCO_2 slope *(which indicates **ventilation efficiency**: how many liters of air the patient must breathe to eliminate one liter of CO_2)* have independent prognostic value and are used, among other things, in the evaluation for advanced therapies (transplantation, ventricular assist devices).
  - **Standard exercise testing (ET)** (without gas exchange measurement) provides useful information such as heart rate, blood pressure, and ECG changes, but remains **an indirect method**, guided by MET (metabolic equivalents) values estimated from the duration and intensity of the exercise, with significant individual variability in patients with heart failure, especially those on beta-blocker therapy.

- **Why does cardiopulmonary exercise testing play a central role?**

Cardiopulmonary testing eliminates this uncertainty by directly measuring oxygen consumption and CO□ production, thereby providing an objective benchmark for the ventilatory threshold—the point at which metabolism becomes predominantly anaerobic, regardless of the patient's chronotropic response to exercise.

  - **VT1—the first ventilatory threshold**, also known as **the aerobic threshold** or *anaerobic threshold* (*AT)*—is the point at which lactate begins to accumulate and ventilation increases faster than oxygen consumption; it corresponds to moderate exercise that can be sustained for a long time, during which one can still speak; in sedentary individuals, it usually occurs at approximately 40–60% of peak VO_2, while in athletes it occurs at a higher percentage; a **VT1** value **below approximately 11 ml/kg/min** indicates a poor prognosis.

- **VT2—the second ventilatory threshold**, also known **as** *the* **respiratory compensation point** (*RCP*) — this is the point at which lactate levels rise rapidly, the body can no longer buffer it, and ventilation increases sharply to eliminate excess CO_2, corresponding to an intense effort that can be sustained only briefly; it typically occurs at approximately 70–90% of peak VO_2.

Practical application: These thresholds divide exercise into **three zones:**

- **below VT1: the light, aerobic zone**
- **between VT1 and VT2: moderate to intense zone**
- **above VT2: the very intense zone**

Based on these thresholds**, training intensity** is determined, both for athletes and in **cardiac rehabilitation**, where patients typically train around VT1.

This last point explains the central role of cardiopulmonary testing in patients with heart failure: most patients are on beta-blocker therapy (which affects **peak heart rate—the maximum heart rate reached at the peak of exercise**), which deliberately limits the increase in heart rate during exercise. In these patients, a prescription based on the theoretical maximum heart rate or on generic MET equivalents systematically overestimates the actual safe exercise capacity, whereas the ventilatory threshold, obtained directly from gas exchange, remains reliable regardless of the degree of beta-adrenergic blockade.

Table 117 . Explanation of terms and parameters assessed by exercise testing (CPET/ET)

Term	Meaning
VT1 (ventilatory threshold 1, aerobic threshold)	The intensity at which ventilation begins to increase disproportionately relative to oxygen consumption, marking the transition from predominantly aerobic metabolism to one with an incipient anaerobic contribution; the safest starting point for training
VT2 (ventilatory threshold 2, anaerobic threshold)	An intensity higher than VT1, at which lactate accumulation exceeds buffering capacity, and the effort becomes predominantly anaerobic; a benchmark for the upper limit of progression
VO_2 (oxygen consumption) / Peak VO_2	The volume of oxygen consumed by the body per unit of time; peak VO2 is the maximum value reached during a cardiopulmonary test, the central benchmark of functional capacity
% of peak HR (percentage of the peak heart rate reached during the test)	Intensity expressed as a percentage of the maximum heart rate actually recorded during testing (not theoretically calculated based on age)
%HRR (percent of heart rate reserve)	Karvonen method: Target HR = resting HR + percentage × (peak HR − resting HR); explicitly accounts for the patient's resting heart rate, unlike the simple % of peak HR
MET (metabolic equivalent)	A unit expressing oxygen consumption as a multiple of resting consumption (1 MET ≈ 3.5 mL O_2/kg/min); used for the general classification of exercise intensity

6. RECOMMENDATIONS FROM THE 2026 ESC GUIDELINES ON CARDIOVASCULAR REHABILITATION REGARDING AEROBIC INTENSITY

6.1. General Principles

1. Time allocation during the session: For patients with heart failure, an exercise session should be structured so that the endurance (aerobic) component accounts for approximately two-thirds of the total duration of the actual exercise, and the strength component for approximately one-third—a principle discussed in detail in chapters 6.13 and 6.17.
2. The preferred benchmark for aerobic intensity: the guidelines explicitly recommend using ventilatory thresholds (VT1, VT2), obtained via TECP, instead of a fixed percentage of maximal effort, whether that be %peak HR, %HRR, or %peak VO_2, since at the same percentage, actual physiological responses (lactate, heart rate, oxygen consumption) vary significantly from one patient to another. Training based on the ventilatory threshold, on the other hand, produces a much more consistent and predictable physiological response across different patients.

For the same reason, the guidelines discourage classifying intensity based on generic metabolic equivalents (METs): these classifications correlate poorly with the actual physiological response to exercise, and for many cardiac patients, an effort of just 4–6 METs may already represent a supramaximal intensity, not a "moderate" one, as the generic classification would suggest.

6.2. Estimating VT1 and VT2 in the Absence of Direct Respiratory Gas Analysis

When respiratory gas analysis is not available, the 2026 ESC guidelines provide formulas for estimating the heart rates corresponding to the two ventilatory thresholds, based solely on the resting heart rate (RHR) and peak heart rate (PHR) obtained during a maximal exercise test:

- **VT1 (ventilatory threshold 1, aerobic threshold)**—the intensity at which ventilation increases disproportionately relative to oxygen consumption, marking the transition from exclusively aerobic metabolism to one with a predominant anaerobic contribution—**represents the safest starting point for training.**
- **VT2 (ventilatory threshold 2, anaerobic threshold)**—a higher intensity at which lactate accumulation exceeds the body's buffering capacity, and metabolism becomes predominantly anaerobic—the benchmark that defines the upper limit of progression toward the consolidation phase of the physical training program, where intensity gradually increases **from below VT1 to VT2 (**VT2 is therefore **the practical ceiling** toward which one progresses throughout the program—not a starting point, nor a value to be routinely exceeded; exceeding it is reserved solely for the interval component (HIIT—*High-Intensity Interval Training*), in stable, carefully selected patients under direct supervision)

Table 118 . Formulas for estimating ventilatory thresholds (VT1, VT2)

Threshold	Estimation formula (heart rates in bpm)
HR at VT1	4.866 + (0.405 × peak HR) + (0.542 × resting HR)
HR at VT2	−2.606 + (0.773 × peak HR) + (0.254 × resting HR)

Practical note: *These formulas provide a reasonably accurate estimate of ventilatory thresholds based on a standard exercise test without gas exchange and represent a superior alternative to simply reporting %Peak HR or %Resting HR when TECP itself is not available.*

6.3. Stratification of exercise intensity based on ergometric parameters:

- MET—metabolic equivalent, a unit expressing oxygen consumption as a multiple of resting oxygen consumption (1 MET ≈ 3.5 mL O_2/kg/min)
- Peak VO_2 = maximum oxygen consumption reached during exercise, measured by CPET
- % Peak HR = percentage of the peak heart rate (Peak HR) actually reached during exercise
- **Heart Rate** Reserve = resting HR + percentage × (peak HR − resting HR)

All four parameters are different ways of expressing *how intense* an exercise is—the first (MET) is an absolute measure of energy expenditure, the second (VO_2) is a direct physiological measure, and the last two (HR, HRR) are ways of relating intensity to the patient's cardiac response.

Table 119 . Exercise intensity guidelines for healthy individuals

Exercise intensity	MET (healthy subject)	% of peak VO2	% of peak HR	% of resting heart rate	Borg Scale
Mild	< 3	< 45%	< 55%	< 40%	< 12
Moderate (up to high, depending on the type of exercise)	3–6	45–85%	55–90%	40–85%	12–17
Intense/vigorous	> 6	> 85%	> 90%	> 85%	> 17

Practical Note: *In patients with heart failure, the columns in the table above should not be interpreted as being directly equivalent to one another: an exercise classified as "moderate" according to MET (3–6) may correspond, in a beta-blocker-treated patient with advanced HFrEF, to an intensity that is already above VT2, and is therefore effectively "intense" from the perspective of that patient's actual ventilatory threshold.*
For this reason, whenever possible, VT1/VT2 remain the reference points, and the other columns (MET, %peak VO_2, %peak HR, %HRR, Borg) are used as practical alternatives, not as perfect synonyms.

- **In patients with heart failure**

In patients with heart failure, the primary benchmark for classifying intensity levels is the position relative to VT1 and VT2, and the other columns are derived from this position, not independent of it.

In patients with heart failure, the VT1 and VT2 reference points are, as a general guideline, approximately:

- ✓ 50–60% of peak VO_2 (VT1, the safest starting point for exercise training in patients at high risk or with severely reduced functional capacity)
- ✓ 65–90% of peak VO_2 (VT2, the upper limit of progression for stable patients with good tolerance).

Table 129. Guidelines for Exercise Intensity in Patients with Heart Failure

Exercise intensity	Main benchmark (VT1/VT2)	MET (patient with HF)	% of peak VO□	% of peak HR (measured)	% of resting heart rate	Borg score
Mild	Below VT1	< 2	< 50%	< 55%	< 30%	< 11
Moderate	At or around VT1, up to VT2	2–4	50–65%	55–75%	30–60%	11–13
Intense (stable, selected patients)	At/near VT2	> 4	65–85%	75–85%	60–80%	14–16

Practical note: *Note the difference from the table for healthy subjects: in heart failure, the MET and percentage thresholds are systematically lower and the ranges narrower, reflecting reduced functional reserve and the effect of the beta-blocker on heart rate; the "intense" range in this table corresponds, roughly, only to the "moderate" range in healthy subjects. The MET, %VO_2*

peak, %HR peak, and %HRR columns remain, as in the general table, practical alternatives used in the absence of CPET, but they are not as precise as directly measured VT1/VT2.

6.4. What specifically changes in patients with heart failure with reduced ejection fraction (HFrEF)?

Table 120 . Parameters used to individualize physical exercise for patients with HFrEF

Table column	What happens in HFrEF/in patients on beta-blockers	Does it remain reliable?
MET	Metabolic equivalent assumes a standard relationship between exertion and oxygen consumption, which no longer holds true in a heart with reduced systolic function; a "4 MET" exertion may already exceed the patient's actual reserve capacity	No, the least reliable column in HFrEF
% of peak HR	Beta-blockers directly reduce the peak HR reached during testing; the percentage remains mathematically correct, but the peak HR used in the calculation is itself "artificially" low, which may lead to an underestimation of exercise tolerance if interpreted in isolation	Partially useful, only if the peak HR comes from a recent test conducted while on current treatment
% RHR (Karvonen)	Slightly more robust than % peak HR, as it also takes resting HR into account (which is often reduced in patients on beta-blockers), but it is still derived from a pharmacologically altered chronotropic response	Partially better than % of peak HR, but inferior to VT1/VT2
Peak $\%VO_2$	Peak VO_2 is measured directly (it does not depend on heart rate), so it remains a valid measure of severity, but the percentage alone does not indicate where the patient stands relative to the actual ventilatory threshold	Yes, as a measure of severity, but not as the sole benchmark for determining exercise intensity
Borg Score	Independent of the beta-blocker's effect on heart rate, it directly reflects the patient's perception	Yes, it remains reliable regardless of treatment, which is why it is the preferred complementary benchmark

Concrete example: a patient with HFrEF, resting HR of 60 bpm, peak HR of 130 bpm during testing while on a beta-blocker. A classic "moderate" exercise, at 70% of peak HR, would mean 91 bpm. However, for the same patient, VT1 estimated using the formula from the previous section may be, for example, 95 bpm, and VT2 at 115 bpm—which shows that the 91 bpm threshold (70% of peak HR) actually falls below VT1, and thus in a more conservative range than the generically applied "moderate" label would suggest. The situation may be reversed in another patient with a different chronotropic profile—which is why **generalizing a single percentage to all patients with HFrEF is unreliable, and individual calculation, using CPET or estimation formulas, remains necessary.**

Summary: *In patients with heart failure, especially those with HFrEF on beta-blockers, the hierarchy of reliability for intensity benchmarks is: VT1/VT2 (measured by CPET) > estimation formulas for VT1/VT2 based on resting HR and peak HR > %HRR > %peak HR > generic classification by MET, the latter being, in practice, unusable as such in this population.*

Beta-blocker therapy, which is administered to most patients with HFrEF as part of FMT (Foundational Medical Therapy), should not be discontinued prior to testing—on the contrary, testing should be performed while the patient is on their current treatment, so that the ventilatory threshold obtained accurately reflects the conditions under which the exercise program will subsequently take place. Any change in the beta-blocker dose following the test requires a reassessment of the threshold, not a simple theoretical recalculation based on the new dose.

Practical note: *For patients with heart failure, it is recommended that the "target heart rate" not be calculated but rather measured—using the ventilatory threshold obtained during CPET—since any formula based on peak heart rate (PHR) is unreliable in a patient on beta-blockers, regardless of how sophisticated the formula may be.*

6.5. Risk stratification prior to enrollment in the rehabilitation program

Table 121 . Risk stratification prior to enrollment in the rehabilitation program

Risk category	Guidance criteria	Implications for inclusion
Low-to-moderate risk	Stable Stage C, NYHA Class I–II, no significant arrhythmias, peak VO_2 above 15–20 ml/kg/min	Direct inclusion, standard follow-up
High risk	NYHA Class III, reduced peak VO_2 (10–15 ml/kg/min), significant associated comorbidities	Enhanced monitoring, slower progression
Very high risk	Recent decompensation (within the last 3 weeks), unstable ventricular arrhythmias, peak VO2 below 10 ml/kg/min	Strictly supervised initiation or postponement until stabilization/reassessment for advanced therapies

Practical note: *Enrolling a patient with heart failure in an exercise program, regardless of phenotype, must always be preceded by confirmation of clinical stability (absence of signs of active decompensation) and explicit risk stratification, not merely knowledge of the ejection fraction alone.*

Summary: *The initial evaluation of a patient with heart failure combines a medical history and clinical examination focused on signs of congestion, a minimal laboratory and diagnostic workup (including mandatory echocardiography and natriuretic biomarkers), cardiopulmonary exercise testing, and explicit risk stratification, all of which must be completed before any decision is made regarding inclusion in the rehabilitation program.*

6.6. The Role of Quality-of-Life Questionnaires

Heart failure-specific questionnaires—such as the Kansas City Cardiomyopathy Questionnaire (KCCQ) or the Minnesota Living with Heart Failure Questionnaire (MLHFQ)—complement the objective assessment with a patient-centered perspective, which is useful for tailoring program goals and monitoring subjective changes in symptoms, in addition to functional and laboratory parameters.

Kansas City Cardiomyopathy Questionnaire (KCCQ)

The KCCQ is a 23-item questionnaire completed by the patient that assesses six domains: physical limitation, symptoms (frequency, severity, recent changes), perceived self-efficacy, social limitation, quality of life, and, optionally, social functioning. Each domain, as well as an overall summary score, is reported on a scale from 0 to 100, where higher values indicate better functional status and quality of life.

Table 122 . Interpretation of the KCCQ Score

KCCQ Score Range	Guideline for interpreting functional status
0–24	Very poor
25–49	Poor
50–74	Moderate
75–100	Good to excellent

A change of at least 5 points in the total score is considered, in the literature, to be the minimum clinically relevant difference—a useful benchmark for distinguishing a genuine improvement attributable to the rehabilitation program from the usual fluctuations in a subjective self-assessment from one visit to the next.

Minnesota Living with Heart Failure Questionnaire (MLHFQ)

The MLHFQ is a 21-item questionnaire structured around three dimensions—physical, emotional, and a residual dimension covering socioeconomic and general aspects—in which the patient rates, on a scale from 0 (not at all) to 5 (very much), how much heart failure has affected them over the past month, for each aspect individually. Unlike the KCCQ, the MLHFQ score is interpreted in reverse: the total score ranges from 0 to 105, and lower values indicate a lesser impact of the disease, and thus a better quality of life.

Practical note: *Be aware of the opposite meanings of the two scales: on the KCCQ, "more" means "better"; on the MLHFQ, "more" means "worse." Confusion between these two directions of interpretation is a common error when using these instruments for the first time and must be explicitly verified before reporting a change as "favorable" or "unfavorable."*

The practical role of these questionnaires in the rehabilitation program

- at the initial assessment, they provide a baseline of the patient's perception of their own illness, which is complementary to—not redundant with—objective parameters (FE, peak VO_2);
- at re-evaluation, they allow for the quantification of an improvement perceived by the patient even when objective functional parameters change more slowly or less noticeably;
- they can signal a clinically relevant discrepancy—for example, objective functional improvement (increased peak VO_2) not accompanied by an improvement in the quality-of-life score, a situation that warrants active investigation (possible causes: anxiety, depression, unrealistic patient expectations);
- support communication with the patient: an objective score, explained in terms the patient can understand, is often more convincing to the patient than a verbal description of progress "measured only by machines."

6.7. Explicit Documentation of the Initial Assessment

It is recommended that the initial assessment form explicitly document each element discussed in this subsection, including the notation "not assessed" when information is unavailable, to avoid misinterpreting an omission as a normal value or the absence of impairment.

This seemingly minor practice prevents a common error in teamwork: a blank field on the form can be interpreted by another person who later takes over the case either as "this information was not obtained" or as "this parameter was normal, which is why nothing was noted"—the two interpretations having completely different consequences for clinical decision-making.

7. RECOVERY IN PATIENTS WITH LOW EJECTION FRACTION (HFrEF)

7.1. Objectives

- improvement in functional capacity (peak VO2, distance on the 6-minute walk test);
- to reduce symptoms (dyspnea, fatigue) at a fixed reference workload;
- to reduce the hospitalization rate for heart failure;
- to improve quality of life, as measured by KCCQ/MLHFQ scores;
- support for social and occupational reintegration, when relevant to the patient.

Table 123 . Detailed objectives by phase of recovery in patients with HFrEF

Phase	Specific, measurable objectives
Phase I (hospitalization/immediately post-event)	Safe mobilization, improvement in tolerance for basic activities, prevention of further deconditioning
Phase II (supervised program, outpatient)	Objective increase in peak VO2 or distance on the 6-minute walk test, reduction in Borg score at a fixed reference workload
Phase III (long-term maintenance)	Maintenance of the functional capacity achieved, reduction in the number of hospitalizations for heart failure, sustained improvement in the KCCQ/MLHFQ score

7.2. Indications

- Stable HFrEF (Class C), NYHA Class I–III, without active decompensation;
- Newly diagnosed HFrEF, already undergoing FMT treatment, at least 2–4 weeks after stabilization;
- Known chronic HFrEF in patients who have not previously benefited from a structured rehabilitation program;
- Post-decompensation HFrEF, once clinically stabilized;
- HFrEF in patients with CRT, LVAD, or post-transplant.

The optimal timing for inclusion varies depending on the patient's clinical course: for newly diagnosed patients, initial MFT titration is typically awaited before formal exercise testing; for patients with known chronic HF, the absence of a prior program is not a contraindication but rather an additional argument for inclusion; and for patients post-decompensation, clinical stability (not merely discharge from the hospital) must be explicitly confirmed.

7.3. Contraindications

- Absolute contraindications: active decompensation, unstable ventricular arrhythmias, severe symptomatic aortic stenosis, acute myocarditis;
- Relative contraindications: recently controlled arrhythmias, symptomatic hypotension, uncorrected moderate-to-severe anemia.

Table 124 . Contraindications to physical training in patients with HFrEF

Absolute contraindications	Relative contraindications
Active decompensation with signs of congestion	Controlled supraventricular arrhythmias without hemodynamic impact
Unstable, uncontrolled ventricular arrhythmias	Mild-to-moderate symptomatic hypotension
Severe, symptomatic aortic stenosis	Moderate, uncorrected anemia
Acute myocarditis or pericarditis	Minor electrolyte disturbances, currently being corrected

7.4. Establishing the safety threshold

- **Based on cardiopulmonary exercise testing (CPET)**

In patients with HFrEF, the ventilatory threshold, identified through cardiopulmonary exercise testing, is the preferred guide for prescribing exercise intensity, as it is more reliable than the classically calculated target heart rate, especially in patients on beta-blocker therapy (discussed in Chapter 9), in whom the chronotropic response to exercise is reduced.
In addition to the ventilatory threshold, CPET provides a comprehensive set of parameters useful for establishing the safety ceiling: peak VO_2 (overall functional capacity), the VE/VCO_2 slope (ventilatory efficiency, with independent prognostic value), and the presence or absence of an adequate chronotropic response—a factor particularly relevant in patients with associated chronotropic incompetence.

Table 125 . Guideline values for CPET parameters in patients with HFrEF

Parameter	Guideline value for HFrEF	Note
Peak VO_2	10–22 ml/kg/min, variable depending on severity (below 14 ml/kg/min suggests advanced disease)	Below 10 ml/kg/min, consideration should be given to evaluating the patient for advanced therapies
Ventilatory threshold	Approximately 50–65% of peak VO_2 (lower than in healthy subjects, where it ranges from 60–70%)	Primary benchmark for intensity adjustment
VE/VCO_2 slope	Class I: <30 (good efficiency); Class II: 30–35.9; Class III: 36–44.9; Class IV: ≥45 (severely reduced efficiency)	Independent prognostic value; Classes III–IV require a more conservative management approach
Peak RER (*Respiratory Exchange Ratio* = **CO_2 exhaled (VCO_2)/O_2 consumed (VO_2)** at peak CPET	≥1.10 confirms a maximal test	Below this threshold, the test is submaximal and the ventilatory threshold should be interpreted with caution

- **Based on the standard exercise test (ET), when CPET is not available**

In the absence of access to cardiopulmonary testing, standard exercise testing (electrocardiographic, without gas exchange measurement) remains an acceptable alternative, with the limitations discussed in the previous chapter: indirect estimation of tolerated intensity via MET equivalents, and reduced reliability of the target heart rate in patients on beta-blockers.

Table 126 . Parameters obtained from the standard exercise test and their use in patients with HFrEF

Parameter obtained during standard exercise testing	**Guideline value / use**
Heart rate at the onset of limiting symptoms or ECG changes	Upper limit; safety margin of 10–15 bpm below this point
Training heart rate, expressed as %HRmax (percentage of the peak heart rate reached during the test)	**Initially 40–50% of peak HR; gradual progression to 60–70% of peak HR, depending on tolerance**
Total test duration / MET equivalent achieved	Frequently 3–7 METs in symptomatic HFrEF; useful for comparison with subsequent reevaluations using the same protocol
Blood pressure response to exercise	Identification of an exaggerated hypotensive or hypertensive response, relevant to the safety of the program
Borg score relative to the maximum intensity reached	Calibration of the patient's subjective perception, useful for subsequent titration using the Borg scale

Practical note: *Standard testing without gas exchange* ***tends to overestimate the actual aerobic capacity in patients with HFrEF on beta-blockers****, due to generic MET equivalence; the safety margin applied to the training heart rate must therefore be more generous than that applied to a ventilatory threshold obtained via CPET.*

Table 127 . TECP versus Standard TE – Comparative Summary for Individualized Prescription

Parameter evaluated	**CPET**	**Standard ET**
Peak VO_2	Measured directly (ml/kg/min); primary marker of severity	Indirectly estimated from METs, with a variability of ±1–2 METs from the actual value
Training heart rate	Derived from the ventilatory threshold (objectively measured), not from a percentage of peak heart rate	Expressed as % of peak HR: 40–50% initially, 60–70% during progression, with an additional margin of 10–15 bpm
Other available parameters	VE/VCO2 slope, RER, pulse O2 (surrogate for stroke volume)	Only test duration and blood pressure/ECG profile
Reliability in Patients on Beta-Blockers	High — the ventilatory threshold is independent of the chronotropic response	Low — %HRpeak calculated based on a chronotropic response already limited by the beta-blocker
Recommended safety margin	10–15 bpm below the ventilatory threshold	10–15 bpm below the limiting heart rate, plus active Borg scale assessment at each session
Availability in practice	Limited to centers with specialized equipment	Widely available in most departments

7.5. The Borg Scale in Heart Failure Rehabilitation

The Borg Scale of subjective perception of exertion (Rating of Perceived Exertion, RPE) quantifies how the patient subjectively perceives the intensity of the exertion, integrating multiple signals—breathing, local muscle fatigue, general discomfort—into a single score that is easy to report verbally during exercise without interrupting it.

- **Why is it particularly useful for patients with heart failure?**

In patients with HFrEF, heart rate—the classic benchmark for gauging intensity—is often unreliable: beta-blocker therapy artificially limits it, cardiac denervation (in post-transplant patients) renders it irrelevant, and some devices (LVADs) generate a partial flow that is independent of it. The Borg scale remains reliable regardless of these particularities, as it directly reflects the patient's perceived exertion, not an intermediate physiological signal that can be altered pharmacologically or surgically.

Table 128 . The Borg Scale—Guidance for Use in the Management of Heart Failure

Score	Verbal descriptor	Guideline for use in heart failure recovery
6	No exertion at all	At rest
7–8	Extremely light	Warm-up, Phase I
9	Very easy	Warm-up, initial mobilization
10–11	Easy	Training initiation phase, NYHA Class III, post-transplant
12–13	Somewhat demanding	Standard aerobic training zone for stable HFrEF
14–15	Demanding (severe)	Progression in a stable, low-risk patient
16–17	Very strenuous	Interval training (HIIT), in selected cases
18–19	Extremely demanding	Avoid in HFrEF, except in strictly supervised interval training protocols
20	Maximal effort	Not a training target in HFrEF

In practice, the patient is instructed to report a number on the scale—not just a qualitative description—as soon as asked to do so during the session, without stopping the exercise. Training the patient in advance on the correct use of the scale—for example, by anchoring a score of 20 to the most intense effort ever experienced in their life and a score of 6 to a state of complete rest—significantly improves the accuracy and reproducibility of subsequent self-assessments.

Practical note: *A steadily increasing Borg score for the same reference task from one session to the next is a warning sign just as important as an objective change in heart rate or blood pressure and should be actively investigated, not automatically attributed to the patient having a "bad day."*

7.6. Functional Tests Useful in Recovery from Heart Failure

For longitudinal monitoring of progress (or, when applicable, regression) in functional capacity, formal exercise testing—CPET or standard exercise testing—is usefully supplemented by a battery of simpler, frequently repeatable tests that do not require the resources needed for a full test. The choice of tests actually used should be tailored to the patient's profile (age, frailty, risk of falling) and not applied identically to everyone.

- **The 6-Minute Walk Test (6MWT)**

The standardized 6-minute walk test (a 30-meter course, with standardized verbal instructions and encouragement, according to the ATS—American Thoracic Society—protocol) measures the maximum distance covered by the patient in six minutes. In HFrEF, a distance of less than 300 meters is associated with a poorer prognosis, and a change of at least 25–30 meters from a previous assessment is considered the minimal clinically important difference (MCID)—a useful benchmark for distinguishing a true improvement (or worsening) from normal test-retest variability.

- **SPPB (Short Physical Performance Battery)**

The SPPB is a battery of tests that assesses static balance (positions with progressively reduced base of support), short-distance walking speed (typically 4 meters), and lower-limb strength (timed sit-to-stand test, 5 repetitions of rising from a chair), with each component scored on a scale of 0 to 4, for a total score ranging from 0 to 12.

Table 139. Interpretation of the SPPB score in patients with heart failure

SPPB Score	Guideline Interpretation
0–6	Reduced physical performance, increased functional risk
7–9	Moderate physical performance
10–12	Good physical performance, low functional risk

- **TUG (Timed Up and Go)**

The TUG test measures the time it takes a patient to stand up from a standard chair, walk 3 meters, turn around, and return to the initial sitting position. A time exceeding 13–14 seconds is associated with an increased risk of falling, which is particularly relevant in older patients with heart failure, who are often on multiple medications and have poor balance.

- **Grip Strength (Dynamometry)**

Measured with a handheld dynamometer, grip strength is a simple and rapid surrogate indicator of overall muscle strength and the risk of sarcopenia, particularly useful in repeated reassessments of the same patient, where the trend over time matters more than the isolated absolute value.

- **Walking Speed**

Walking speed, measured over a short, standardized distance (4 or 10 meters, at a comfortable pace chosen by the patient), is a simple indicator with documented independent prognostic value in the elderly population; a speed below 0.8 m/s is considered a guideline threshold for functional frailty.

Table 140. Other useful tools for monitoring progress

Tool	What it assesses	Practical advantage
ISWT (Incremental Shuttle Walk Test)	Walking capacity, with progressively increasing speed, guided by an audible signal	Closer to a graded exercise test than the 6MWT, without specialized equipment
KCCQ/MLHFQ questionnaires	The patient's perception of the disease's impact	Captures benefits perceived by the patient, sometimes before objective changes occur
Body weight and Borg score during a fixed-load exercise	Volumic status; subjective tolerance over time	Monitored at every session, without additional resources

Practical note: *None of these simple tools replaces a formal reassessment via CPET or standard TE at scheduled intervals (typically at the end of Phase II); however, they serve to detect early signs of favorable or unfavorable progression between these formal reassessments, and their combination—functional (6MWT, SPPB), strength (dynamometry), mobility (TUG, walking speed), and subjective perception (questionnaires, Borg)—provides a more complete picture than any single test.*

7.7. Special Precautions for Patients with HprEF Enrolled in the Rehabilitation Program

- check body weight and signs of congestion before each session, regardless of the type of test used to establish the threshold;
- be alert for exercise-induced hypotension, which is common in patients receiving high doses of ACE inhibitors/ARBs and concomitant diuretics;
- active monitoring for arrhythmias in patients with a history of ventricular arrhythmias, even if controlled, with easy access to emergency equipment;
- in patients with documented chronotropic incompetence on CPET, avoid basing dosing exclusively on heart rate; instead, use the Borg scale as a mandatory complementary reference;

- the progression of exercise intensity must always be more conservative than in cardiac patients without significant systolic dysfunction, regardless of the type of test used to establish the initial threshold.

Table 129 . Warning signs during the session and immediate management in patients with HFrEF

Warning sign during the session	Immediate management
Dyspnea disproportionate to the prescribed intensity	Stop the session, check recent body weight, reassess fluid status
Symptomatic hypotension on exertion (dizziness, presyncope)	Stop the session, have the patient sit or lie down, check for recent diuretic or vasodilator therapy
New-onset palpitations or irregular pulse	Stop the session, check ECG if available, promptly notify the coordinating physician
Borg score significantly higher than in previous sessions, at the same workload	Reduce the intensity for the current session; this is a sign of possible early deterioration and should be investigated before the next session

7.8. Structuring the Physical Training Program

- **Based on the parameters obtained from the CPET**

Table 130 . Structuring the program based on CPET parameters for the patient with HFrEF

Program Stage	Intensity benchmark (specific values)	Note
Initial phase (2–3 weeks)	Below the ventilatory threshold (approx. 40–50% of peak VO_2); short sessions (10–15 minutes)	Conservative progression, especially in NYHA Class III or with a peak VO_2 below 14 ml/kg/min
Progression phase (weeks 4–8)	At or slightly above the ventilatory threshold (approx. 50–65% of peak VO_2); duration gradually extended to 20–30 minutes	Interval training may be considered in stable patients with low-to-moderate risk
Consolidation phase	Maintenance at 60–75% of peak VO_2, with periodic reassessment via CPET	Formal reassessment, not subjective extrapolation, guides any further increase

- **According to the parameters obtained from standard echocardiography**

In the absence of a CPET, the program is structured according to the same three phases, with one key difference in approach: the heart rate ceiling established during the standard exercise test is treated as a provisional benchmark, actively verified using the Borg scale at each session, rather than as a definitive value.

Table 131 . Program structuring based on the standard exercise test in patients with HFrEF

Program Stage	Intensity benchmark (specific values, standard exercise test)	Note
Initial phase (2–3 weeks)	40–50% of peak HR (10–15 bpm below the limiting heart rate during the standard exercise test); target Borg score 10–11	An even more conservative progression than in the CPET-guided approach, given the higher degree of uncertainty
Progression phase (weeks 4–8)	50–65% of peak heart rate, with increases explicitly contingent on a stable or decreasing Borg score at the same workload	Any discrepancy between the "allowed" heart rate and the subjective perception of intense effort must give priority to the subjective perception
Consolidation phase	60–70% of peak heart rate; reassess-ment via standard exercise testing at 8–12 weeks, ideally with a transition to CPET if it becomes available	A formal reassessment remains necessary even in the absence of CPET

Practical note: *Regardless of whether the safety threshold is derived from CPET or standard exercise testing, the principle remains the same: any increase in intensity beyond the initial ceiling must be justified by an objective reassessment, not by an extrapolation based on the patient's apparently good subjective tolerance.*

7.9. The FITT-VP Principles in the Rehabilitation Program for Patients with HFrEF

The 2026 ESC Guidelines for Cardiac Rehabilitation structure exercise prescriptions according to the FITT-VP principle (Frequency, Intensity, Time/Duration, Type, Volume, Progression), which expands upon the classic FITT (Frequency, Intensity, Time, Type) by adding two additional parameters—total exercise volume and an explicit progression strategy—that are essential for complete individualization in patients with HFrEF.

The guideline also recommends that the intensity benchmark be based, whenever possible, on the ventilatory threshold obtained via CPET, rather than on a fixed fraction of maximum heart rate or peak VO_2 (%HRmax, %HRR, or %VO_2peak): at the same percentage, individual physiological responses (lactate, heart rate, oxygen consumption) vary significantly among patients, whereas training relative to the ventilatory threshold produces a more homogeneous physiological response. Percentage benchmarks (%HRR, %VO_2peak) remain, however, a valid practical alternative when CPET is not available.

- **Aerobic component—continuous versus intervals, frequency, duration, intensity**

The aerobic (endurance) component accounts for the majority of each session's duration in patients with HFrEF—roughly two-thirds of the total exercise time, with the remaining one-third allocated to the strength component, when included.

Table132 . Parameters of the aerobic component in patients with HFrEF

Parameter	Guideline value for HFrEF (adapted from the 2026 ESC guidelines)
Frequency (aerobic)	Progression from 2–3 days/week at the start of the program to 3–5 days/week, as tolerance allows
Duration per session (aerobic)	Progress from 15–30 minutes at the start to 45–60 minutes in a patient with good tolerance
Intensity (aerobic)	Moderate to moderately high; low intensity for selected patients at high risk or with severely reduced functional capacity
Approximate weekly energy intake	Over 1,000 kcal/week, as a medium- to long-term goal

Continuous, moderate-intensity aerobic exercise remains the standard form of exercise, with the best-documented safety profile. Interval training (alternating short periods of high intensity with periods of active recovery) may be considered in stable patients with low-to-moderate risk, without significant residual ischemia and without unstable arrhythmias, under close supervision, with some evidence suggesting an additional benefit on peak VO_2, although the individual response remains variable and cannot be generalized to all patients with HFrEF.

- **Continuous versus Interval Training (HIIT) in HFrEF**

High-intensity interval training may be considered in stable patients with low-to-moderate risk (without significant residual ischemia or unstable arrhythmias), under close supervision, with data suggesting an additional benefit on peak VO2, although the individual response is variable.

- **Resistance Training in HFrEF and Combating Sarcopenia**

Light-to-moderate-intensity resistance training is recommended as a complement to aerobic exercise in patients with HFrEF, with favorable effects on peripheral muscle mass and functional autonomy, particularly relevant in patients at risk for sarcopenia or cardiac cachexia
As a guideline, resistance training for HFrEF begins with 1–2 sets of 10–15 repetitions at an intensity perceived as "light to moderate" (Borg 11–13) for large muscle groups, 2–3 times per week, on alternate days with the aerobic component or immediately following it.

Table 133 . Intensity Zones – Comparative Guide for HFrEF

Zone	% of HRR or relative to ventilatory threshold	% of peak HR (if standard ECG)	Borg score	Use
Very mild	< 30% of HRR, well below the ventilator threshold	< 40% peak heart rate	6–9	Warm-up, Phase I
Mild to moderate	30–50% HRR, below the ventilatory threshold	40–50% of peak heart rate	10–11	Program initiation, NYHA Class III
Moderate	50–70% of resting heart rate, at or near the ventilatory threshold	50–65% of peak heart rate	12–13	Standard training zone
Intense	70–85% of HRR, above the ventilatory threshold	65–70% of peak heart rate	14–16	Interval training, selected patients

Summary: *Rehabilitation in patients with HFrEF combines an individualized prescription, guided primarily by the ventilatory threshold obtained during cardiopulmonary exercise testing or, in the absence thereof, by a threshold established through standard testing with a more generous safety margin, supported by the Borg scale and simple tools for monitoring progress (6MWT, quality-of-life questionnaires), with specific adaptations for subgroups receiving CRT, post-transplant, or with an LVAD, all aimed at the same central goal: improving functional capacity and quality of life.*

Strength Component (Muscle Resistance Training)

Table 134 . Parameters of muscle strength training in patients with HFrEF

Parameter	Guideline value for HFrEF (adapted from the 2026 ESC guidelines)
Frequency	At least 2 days/week, typically on alternate days with the aerobic component or immediately following it
Sets and repetitions	Progress to at least 2 sets per major muscle group, 8–15 repetitions per set
Intensity	Progress to 40–60% of 1RM (one-rep maximum), starting with low volume and intensity in the first few weeks

At the start of the program, both the volume (number of sets/reps) and the intensity of resistance training should be deliberately reduced to allow the patient time to become familiar with proper form before gradually increasing the workload—a principle particularly important for older patients or those with associated sarcopenia.

- **Balance and Flexibility/Mobility**

Although supported by evidence that is less robust than that for the aerobic and strength components, balance exercises and joint flexibility/mobility exercises are recommended as complementary elements of the program, particularly for older patients or those with a documented risk of falling (e.g., as determined by the TUG test). Balance exercises can be integrated directly into the warm-up or cool-down portion of the session without requiring significant additional time, while gentle, active joint mobilization is particularly useful for patients who have been sedentary for extended periods or have recently been hospitalized.

- **Respiratory Muscle Training**

Inspiratory muscle training, performed using a dedicated respiratory resistance device, is particularly useful in patients with documented weakness of the inspiratory muscles—a common finding in HFrEF—and can be combined with aerobic and strength training components when tolerated.

Table 135 . Parameters of respiratory muscle training in patients with HFrEF

Parameter	**Guideline value for HFrEF (adapted from the 2026 ESC guidelines)**
Frequency	3–5 sessions/week, up to daily
Duration per session	20–30 minutes
Intensity	Progression from 30% to 60% of maximum inspiratory pressure

Practical note: *Evidence regarding the additional benefit of inspiratory muscle training, when added to aerobic and strength training, remains limited and inconsistent; the decision to include it must be individualized, not systematically applied to all patients with HFrEF, and is generally reserved for those with documented inspiratory weakness.*

- **Structure of a Physical Training Session: Phases, Duration, and Weekly Frequency**

A typical rehabilitation session for a patient with HFrEF can be structured into time segments, adapted to the total available duration (approximately 45–60 minutes for a patient in the consolidation phase, shorter in the initial phase).

Table 136 . Structure of a physical training session for patients with HFrEF

Phase	Approximate duration	Content
Initial assessment	5 minutes	Body weight, signs of congestion, blood pressure, resting heart rate, Borg score from the previous day
Warm-up	5–10 minutes	Active joint mobilization, light balance exercises, gradual increase in heart rate
Aerobic component	20–40 minutes (approximately two-thirds of the actual exercise time)	Continuous or interval training, at the intensity determined by CPET or standard ET
Strength component	10–15 minutes (approximately one-third of the actual exercise time)	Exercises for large muscle groups
Balance (if not included in the warm-up)	5 minutes	Simple exercises, with or without support
Cool-down	5–10 minutes	Gradual reduction in intensity, light flexibility/mobility exercises
Final check	5 minutes	Post-exercise heart rate and blood pressure, peak Borg score, reported symptoms
Intra-session breaks	As needed, especially in the initial phase or during interval training	Active or passive recovery between sets/intervals, without strict timing for patients with more severe symptoms

The recommended weekly frequency follows the same progression logic: 2–3 sessions per week at the start of the program (initial phase), gradually increasing to 3–5 sessions per week as tolerance improves (progression and consolidation phase), combining, whenever possible, supervised sessions at the facility with additional sessions performed independently by the patient at home, at a previously validated intensity.

Summary: *Tailoring the program to patients with HFrEF, according to the FITT-VP principle, incorporates a predominantly aerobic component (approximately two-thirds of the session duration), supplemented by strength, balance, and flexibility training, and, in selected cases, inspiratory muscle training, structured into a session with clear sequences (assessment, warm-up, active components, cool-down, final assessment) and a gradual progression in both weekly frequency and the intensity of each component.*

7.10. Benefits and Expected Outcomes

Physical training in patients with stable HFrEF is supported by robust evidence regarding improvements in functional capacity and quality of life, as well as a reduction in the rate of hospitalization for heart failure, with a Class I recommendation in current guidelines, and no increased risk of adverse events when properly prescribed and supervised.

Table 137 . Benefits and expected outcomes of exercise training in patients with HFrEF

Domain	Expected Outcome
Functional capacity (peak VO_2)	Typically a 10–25% increase, variable by individual, with a better response in patients who were initially more symptomatic
6-minute walk test	Frequently exceeds the 25–30-meter threshold considered clinically relevant
Overall physical performance (SPPB, TUG)	Improvement in SPPB score and reduction in TUG time, particularly relevant in elderly or frail patients
Muscle strength	Increase in grip strength and lower-limb strength, with an impact on functional autonomy
Symptoms	Reduction in dyspnea and fatigue at a fixed reference workload, as measured by the Borg scale
Hospitalization	Documented reduction in the hospitalization rate for heart failure (HF-ACTION study)
Quality of life	Improvement in KCCQ/MLHFQ scores, often evident before echocardiographic changes
Peripheral mechanisms	Improvement in myocardial capillary density and endothelial function, independent of changes in ejection fraction
Neurohormonal profile	Partial reduction in chronically elevated sympathetic tone, with a potential benefit regarding ventricular arrhythmias
Respiratory function (if IMT is included)	Improved inspiratory muscle strength, with a potential benefit regarding dyspnea, in patients with documented inspiratory weakness
Psychological well-being	Reduction in anxiety and depression symptoms and increased confidence in one's own ability to exercise
Mortality	Favorable findings in adjusted analyses of large studies, although the benefit on mortality alone remains less robust than that on functional capacity and hospitalization

It is important to note that not all of these benefits occur simultaneously or to the same extent in every patient: some patients respond primarily in terms of objective functional capacity, while others respond mainly in terms of perceived quality of life or overall physical performance; therefore, program reassessment must consider the full spectrum of outcomes, not just a single parameter in isolation.

7.11. Characteristics of Recovery in Special Patient Groups

- **Patients undergoing cardiac resynchronization therapy (CRT)**

In patients with HFrEF and significant left bundle branch block, cardiac resynchronization therapy (CRT), through biventricular pacing, improves the synchrony of contraction and, in responders, the ejection fraction. The rehabilitation program for these patients follows the general principles for HFrEF, with additional reported benefits regarding exercise capacity, attributed to both resynchronization and physical training itself. Assessing the response to CRT via follow-up echocardiography at 3–6 months is useful for recalibrating the program's goals.

- Specific considerations for CPET/ET: the ventilatory threshold or limiting frequency must be reevaluated after device optimization (typically at 3 months), as resynchronization can significantly alter functional capacity compared to the pre-implantation assessment, with reported increases in peak VO_2 of up to 15–20% in responders;

- Specific mechanical precaution: Avoid extensive movements of the arm on the same side as the implant site for 4–6 weeks after the procedure, regardless of the exercise test result.

- **The Heart Transplant Patient**

Post-heart transplant patients exhibit key physiological characteristics, particularly cardiac denervation: the resting heart rate is typically higher (often 90–110 bpm), its increase at the onset of exercise is delayed, and the return to resting values is also slower. These characteristics require a longer warm-up period and an intensity prescription based primarily on the patient's subjective perception of exertion (the Borg scale), rather than on the classically calculated target heart rate. The absence of typical anginal pain, due to denervation, means that warning signs are often atypical (marked dyspnea, unusual fatigue), requiring particularly careful monitoring of these manifestations.

- Special considerations for CPET/ET: even cardiopulmonary testing must be interpreted with caution—the ventilatory threshold remains useful for peak VO_2, but the heart rate at this threshold is unreliable due to denervation, which is why the Borg scale obtained simultaneously during testing becomes the central reference to be incorporated into the prescription (indicative Borg target of 12–14 for the standard training zone);

Practical Note: *In post-transplant patients, monitoring should pay particular attention to unusual dyspnea or fatigue in the absence of typical chest pain, which does not occur due to cardiac denervation.*

- **Patients with a left ventricular assist device (LVAD)**

In patients with advanced HFrEF who have a left ventricular assist device (LVAD), whether as destination therapy or as a bridge to transplantation, the rehabilitation program aims to improve functional capacity and quality of life, with specific precautions regarding the external power lead (driveline)—avoiding traction or trauma at this site—and monitoring device-specific parameters, as well as the risk of associated right ventricular failure, a relatively common complication in this population.

- Specific considerations for CPAP/CPP: the flow generated by the device is partially independent of the patient's own heart rate; therefore, the safety threshold must be established in direct collaboration with the team managing the device, rather than extrapolated from general HFrEF principles; the Borg scale remains, as in the post-transplant setting, the most useful practical benchmark;
- Specific mechanical precaution: Securely fasten the external power line before any exercise session, avoiding movements that could cause traction at the exit site.

8. RECOVERY IN PATIENTS WITH PRESERVED EJECTION FRACTION (HFpEF)

8.1. Pathophysiological Features Relevant to Prescribing

Unlike HFrEF, in which functional impairment is dominated by systolic dysfunction, in HFpEF the dominant mechanism is myocardial stiffness and diastolic dysfunction, frequently associated with a pattern of multimorbidity (obesity, hypertension, atrial fibrillation, diabetes), which often influences the patient's exercise capacity more than isolated cardiac dysfunction.

8.2. Objectives

- improvement of functional capacity (peak VO2, distance covered in the 6-minute walk test);
- to reduce symptoms (dyspnea, fatigue) at a fixed reference workload;
- integrated management of associated comorbidities (obesity, hypertension, atrial fibrillation, diabetes), which often cause greater functional limitation than isolated diastolic dysfunction;
- improvement in quality of life, as measured by KCCQ/MLHFQ scores;
- in patients with associated obesity, support for weight loss, complementing nutritional intervention and, in selected cases, pharmacological treatment.

Table 138 . Detailed objectives by phase of recovery in patients with HFpEF

Phase	Specific, measurable objectives
Phase I	Safe mobilization, initial blood pressure control, prevention of further deconditioning
Phase II (supervised program)	Targeted increase in peak VO2 or 6MWT distance, improvement in blood pressure control during exercise, reduction in Borg score at a fixed reference workload
Phase III (maintenance)	Maintenance of functional capacity, sustained management of comorbidities, sustained improvement in KCCQ/MLHFQ scores

8.3. Indications

- Stable HFpEF, confirmed by echocardiography (EF ≥50%, with associated criteria for diastolic dysfunction, as defined by: elevated NT-proBNP above 125 pg/ml in sinus rhythm/above 365 pg/ml in patients with atrial fibrillation; structural changes: left atrial dilation (LAD) and left ventricular hypertrophy (LVH); direct evidence of elevated left ventricular filling pressures on echocardiography (elevated E/e' ratio/other Doppler parameters of diastolic function), or, when echocardiography is inconclusive, through direct invasive measurement (right heart catheterization, with elevated blocked pulmonary capillary pressure at rest or during exercise).
- HFpEF with associated multimorbidity (obesity, hypertension, atrial fibrillation, diabetes), in which rehabilitation offers an opportunity for integrated management;
- HFpEF in elderly patients, with or without associated frailty, with appropriate adjustment of exercise intensity and type.

8.4. Contraindications

- Absolute contraindications: similar to those discussed for HFrEF — active decompensation, unstable ventricular arrhythmias, severe symptomatic aortic stenosis;
- Relative contraindications: uncontrolled hypertension at the time of evaluation (more common in HFpEF than in HFrEF), atrial fibrillation with inadequate rate control.

Table 139 . Contraindications to exercise training in patients with HFpEF

Absolute contraindications	Relative contraindications
Active decompensation with signs of congestion	Uncontrolled hypertension at evaluation
Unstable, uncontrolled ventricular arrhythmias	Atrial fibrillation with inadequate rate control
Severe, symptomatic aortic stenosis	Severe obesity with associated mechanical limitations (joint, respiratory)

8.5. Pathophysiological features relevant to prescribing

Unlike HFrEF, in which functional limitation is dominated by systolic dysfunction, in HFpEF the dominant mechanism is myocardial stiffness and diastolic dysfunction, frequently associated with a pattern of multimorbidity (obesity, hypertension, atrial fibrillation, diabetes), which often influences the patient's exercise capacity more than isolated cardiac dysfunction.

8.6. Establishing the Safety Threshold

- **Based on the cardiopulmonary exercise test (CPET)**

In HFpEF, the ventilatory threshold remains the preferred benchmark for determining exercise intensity, following the same principles discussed for HFrEF, but with an additional observation: in this population, cardiopulmonary exercise testing is useful not only for determining exercise intensity but also for differentiating the relative contributions of various possible causes of dyspnea.

Table 140 . Guideline values for CPET parameters in patients with HFpEF

Parameter	Guideline Value for HFpEF	Note
Peak VO_2	12–20 ml/kg/min, typically less severely reduced than in advanced HFrEF, but further limited by comorbidities	Interpretation should be integrated with the comorbidity profile, not in isolation
Ventilatory threshold (VT1)	Approximately 50–60% of peak VO2	The primary guide for determining aerobic exercise intensity
VE/VCO2 slope	Often mildly to moderately elevated; severely elevated values suggest associated pulmonary hypertension	Indication for referral for further cardiological evaluation if severely elevated
Blood pressure response to exercise	Often exaggerated (disproportionate increase in systolic blood pressure)	A limiting factor as relevant as the ventilatory threshold in this population

- **Based on the standard exercise test (ET)**

In the absence of CPET, the same principles discussed for HFrEF apply: peak heart rate measured during testing, with a safety margin of 10–15 bpm, actively verified using the Borg scale. In HFpEF, monitoring the blood pressure response to the standard ET is at least as important as monitoring heart rate, given the more common hypertensive profile of this population.

Table 141 . TECP versus standard echocardiography in HFpEF—comparative summary

Aspect	CPET	Standard ET
Primary Use	Assessment + differentiation of causes of dyspnea	Guideline dosage, without etiological differentiation
Intensity benchmark	Ventilatory threshold (VT1)	% of peak heart rate or % of resting heart rate, with an additional margin
Blood pressure monitoring	Integrated into the standard testing protocol	Equally important, it must be explicitly documented
Availability	Limited to specialized centers	Widely available

8.7. The Borg Scale in Patients with HFpEF

The principles of the Borg scale, described in detail for HFrEF, apply unchanged to HFpEF. One distinction: in patients with HFpEF and an exaggerated blood pressure response to exercise, a sudden increase in the Borg score may signal this hypertensive response—just as relevant as signaling ischemia or arrhythmia in patients with HFrEF—which is why prompt reporting of the score remains equally important in this phenotype.

8.8. Useful Tests for Monitoring Progress in HFpEF

The battery of tests discussed for HFrEF—6MWT, SPPB, TUG, grip strength, and walking speed)—applies identically to HFpEF, with an additional relevance: in this population, which is often elderly and multimorbid, tests of overall physical performance (SPPB, TUG) may be at least as valuable in practice as aerobic testing alone, given the impact of comorbidities on overall mobility.

8.9. Differential Diagnosis of Dyspnea in Patients with HFpEF

In patients with HFpEF, exertional dyspnea may have multiple concurrent causes—diastolic dysfunction, obesity, deconditioning, associated lung disease— which is why cardiopulmonary exercise testing is particularly useful for differentiating the relative contribution of each mechanism, thereby guiding a more precisely targeted intervention than a generic approach based solely on the diagnosis of heart failure.

8.10. Special Precautions

- active monitoring of the blood pressure response during each session, not just heart rate, given the frequently hypertensive profile of this population;
- Verify control of ventricular rate during exercise, not just at rest, in patients with associated atrial fibrillation;
- Adapt the type of exercise to the mechanical limitations imposed by obesity or joint comorbidities, which are common in this phenotype;
- checking pre-exercise blood glucose levels in patients with associated diabetes, in accordance with general principles.

Table 142 . Warning signs during the session and immediate management in patients with HFpEF

Warning sign during the session	Immediate management
Marked, disproportionate increase in systolic blood pressure	Immediately reduce the intensity or stop the session; reevaluate antihypertensive treatment
Irregular pulse with symptoms in a patient with known AF	Stop the session, check heart rate control, and contact the coordinating physician
Marked dyspnea disproportionate to the prescribed intensity	Stop the session; consider a concurrent non-cardiac cause

8.11. Structure of a physical training session: phases, duration, and weekly frequency

- **Based on the CPET result**

Table 155. Program structuring based on the CPET result in patients with HFpEF

Program Stage	Intensity Level	Note
Initial phase (2–3 weeks)	Below the ventilatory threshold; short sessions (10–15 minutes)	Conservative progression, especially in elderly patients or those with significant multimorbidity
Progression phase (weeks 4–8)	At or slightly above the ventilatory threshold; duration gradually extended	Progression explicitly contingent on blood pressure control, not just cardiac/respiratory tolerance
Consolidation phase	Maintenance at moderate intensity, with periodic reassessment	Reassessment must explicitly include the status of comorbidities, not just cardiac parameters

- **Depending on the result of standard echocardiography**

In the absence of CPET, the same three phases apply, with the %HRmax benchmarks discussed for HFrEF actively verified using the Borg scale and, for HFpEF, equally verified through blood pressure monitoring at each session.

- **Aerobic component—frequency, duration, intensity**

Moderate-intensity continuous aerobic training remains the preferred form for HFpEF, with more limited data on the safety and additional benefit of high-intensity interval training (HIIT) compared to HFrEF. Frequency and duration follow the general principles discussed for HFrEF (Chapter 6.13: progression from 2–3 to 3–5 days/week, from 15–30 to 45–60 minutes/session), with a progression that is often slower than in HFrEF due to associated multimorbidity.

- **Strength Training**

Resistance training is recommended, as with HFrEF, with an additional emphasis on combating sarcopenia associated with obesity or advanced age—conditions common in this phenotype—sometimes in the specific form of sarcopenic obesity.

- **Balance and Flexibility/Mobility**

Given the frequently elderly and multimorbid profile of patients with HFpEF, balance exercises and joint mobility exercises are at least as important for this phenotype as they are for HFrEF and are often prioritized over aggressive progression of the aerobic component.

- **Training of the inspiratory muscles**

The principles discussed for HFrEF apply similarly to HFpEF, with the same caveat regarding the limited evidence and the need for individualization, especially in patients with documented inspiratory weakness.

- **The Role of Weight Loss in Patients with HFpEF and Obesity**

In patients with HFpEF and associated obesity, weight loss—achieved through a combination of nutritional intervention, physical exercise, and, in selected cases, pharmacological therapy (GIP/GLP-1 agonists)— directly improves functional capacity by reducing the metabolic demand of exercise and, possibly, by directly improving cardiac hemodynamics—a mechanism currently under investigation.

8.12. Benefits and Expected Outcomes

Physical training in patients with HFpEF improves functional capacity and quality of life, with a safety profile similar to that seen in HFrEF; the 2026 ESC guidelines additionally mention a role for

dual GIP/GLP-1 agonists (semaglutide, tirzepatide) in patients with HFpEF and associated obesity, with a Class IIa recommendation, as a complement to—not an alternative to—the exercise program.

Table 143 . Benefits and expected outcomes of physical training in patients with HFpEF

Domain	**Expected Outcome**
Functional capacity (peak VO_2)	Documented improvement, with magnitude varying depending on the degree of multimorbidity
6-minute walk test	Increase frequently above the clinically relevant threshold of 25–30 meters
Blood pressure control	Improved blood pressure response to exercise, complementary to antihypertensive treatment
Overall physical performance (SPPB, TUG)	Significant improvement, especially in frail older adults
Symptoms	Reduction in dyspnea at a fixed reference workload
Quality of life	Improvement in KCCQ/MLHFQ scores
Body weight status (if obesity is present)	Sustained weight loss, with direct functional benefit, especially if supported by medication (GIP/GLP-1 agonists)
Metabolic comorbidities	Improved glycemic control and, indirectly, the overall cardiovascular profile

Summary: *Recovery in patients with HFpEF follows principles similar to those in HFrEF—structured assessment, individualized safety threshold, FITT-VP training structured around aerobic, strength, balance, and inspiratory muscle components, but with an explicit emphasis on integrated management of comorbidities, on blood pressure control as a limiting factor at least as important as the ventilatory threshold, and, in selected cases, on pharmacologically supported sustained weight loss.*

9. RECOVERY AFTER CARDIAC SURGERY

- **Recovery after coronary artery bypass grafting (CABG)**

In patients with heart failure secondary to coronary artery disease who have undergone CABG, recovery follows the classic principles of cardiac surgery—early mobilization, breathing exercises, and sternal protection for 6–8 weeks (avoiding arm strain and heavy lifting), depending on the patient's residual ejection fraction.

- **Recovery After Valvular Surgery**

In patients with valvular heart failure that has been surgically corrected (replacement or repair), recovery must take into account the type of prosthesis (mechanical, requiring chronic anticoagulation, or biological) and the degree of postoperative ventricular function recovery, which is often incomplete and progressive during the first few months; for this reason, an echocardiographic reevaluation 3–6 months postoperatively is useful for adjusting the program's goals.

- **General Postoperative Precautions**
  - sternal precautions: avoid raising the arms above shoulder level and lifting weights over 4–5 kg for 6–8 weeks;
  - monitor the sternal wound for signs of dehiscence or infection (redness, discharge, instability on palpation);
  - in patients with a venous graft harvested from the lower extremity, pay attention to edema and mobilization of that limb;
  - Reassess postoperative ventricular function, as recovery may be gradual rather than immediate, which influences risk stratification.

Practical Note: *The exact type of surgical procedure and its date must be explicitly known to the rehabilitation team prior to any exercise session, as mechanical precautions differ significantly depending on the surgical approach used.*

Table 157. Approximate Timeframes for Resuming Activities

Activity	Approximate Timeline
Light walking, light household activities	Starting during hospitalization, gradually
Driving	Approximately 4–6 weeks, with the attending physician's approval
Lifting weights over 4–5 kg	After sternal healing, 6–8 weeks
Return to sedentary work	Approximately 4–6 weeks
Return to physically demanding work	Approximately 3 months, on an individual basis

- **Postoperative complications relevant to the physical therapist**
  - sternal dehiscence — instability or crepitus at the sternum, requiring immediate discontinuation of upper-body exercises;
  - postoperative atrial fibrillation — common; requires reassessment of exercise tolerance and consideration of anticoagulation status;
  - pericardial effusion — dyspnea, hypotension, tachycardia; requires suspension of the exercise program and urgent cardiological evaluation.

Summary: *Recovery after cardiac surgery in patients with heart failure combines classic mechanical precautions—related to sternotomy and the type of valve prosthesis—with the specific principles of exercise prescription discussed for HFrEF and HFpEF; individualization depends on the residual ejection fraction and the postoperative course of each patient.*

10. MANAGEMENT OF RISK FACTORS AND PHARMACOLOGICAL TREATMENT

- **Foundational Medical Therapy (FMT) and Interaction with Exercise**

The 2026 ESC Guidelines introduce a new classification of drug therapy, distinguishing foundational medical therapy (FMT) from add-on therapy (AMT) and guideline-directed interventional therapy (GDIT), with the umbrella term GDMT (guideline-directed medical therapy) encompassing both FMT and AMT. In patients with HFrEF, FMT consists of a beta-blocker, a renin-angiotensin system inhibitor (ACEI/ARNI/BRA), a mineralocorticoid receptor antagonist (MRA), and an SGLT2 inhibitor; in patients with HFpEF, FMT consists of an MRA and an SGLT2 inhibitor.

- **Foundational Medical Therapy (FMT) and Interaction with Exercise**

The 2026 ESC Guidelines introduce a new classification of drug therapy, distinguishing foundational medical therapy (FMT) from add-on therapy (AMT) and guideline-directed medical therapy (GDMT), with the umbrella term GDMT remaining the overarching category for both FMT and AMT. In patients with HFrEF, FMT consists of a beta-blocker, a renin-angiotensin system inhibitor (ACEI/ARNI/BRA), a mineralocorticoid receptor antagonist (MRA), and an SGLT2 inhibitor; in patients with HFpEF, FMT consists of an MRA and an SGLT2 inhibitor.

Table144 . Fundamental Medication Therapy (FMT) and Interaction with Exercise

Therapeutic class	Relevance to rehabilitation practice
Beta-blockers	Limit the increase in heart rate during exercise; the Borg scale is preferred for determining exercise intensity
ACE inhibitors/ARBs/β-blockers	Reduce afterload; watch for hypotension, especially at the start of treatment
Mineralocorticoid receptor antagonists (MRAs)	Class I recommendation regardless of ejection fraction, according to the 2026 guidelines; risk of hyperkalemia
SGLT2 inhibitors	Mild diuretic effect; be mindful of hydration, especially in hot weather

- **Diuretics and volume management in the context of exercise**

Although diuretics are not part of the FMT, they remain essential for the symptomatic control of congestion; recent adjustments to the diuretic dose may influence exercise tolerance and the risk of orthostatic hypotension, which is why the recovery team must be informed of any recent changes to this treatment.

- **Anticoagulation in Patients with Associated Atrial Fibrillation**

In patients with heart failure and associated atrial fibrillation, oral anticoagulation—when indicated—requires attention to the risk of bleeding during exercise, with avoidance of activities carrying a significant risk of impact or falls, a principle discussed at length in other materials in this course dedicated to antithrombotic management.

- **Add-on therapy (AMT) and guided interventional therapy (GDIT)**

In addition to FMT, the 2026 ESC guidelines describe add-on therapy (AMT), which includes, depending on the context, ivabradine, digoxin, or the hydralazine-nitrate combination—reserved for patients who remain symptomatic despite full FMT—and guided interventional therapy (GDIT), which encompasses devices (CRT, ICD) and structural procedures (e.g., transcatheter mitral valve repair), indicated for specific patient subgroups.

Practical note: *The AMT/GDIT terminology does not imply a hierarchy of "secondary importance," but rather reflects the fact that these therapies are reserved for specific subgroups,*

unlike FMT, which is applicable to virtually all patients with the respective phenotype, in the absence of contraindications.

Summary: *The FMT/AMT/GDIT terminology, introduced by the 2026 ESC guidelines, reorganizes the pharmacological treatment of HF without fundamentally changing the known therapeutic classes; the rehabilitation team must be familiar with the effects of these classes on exercise response—particularly those of beta-blockers and diuretics—to correctly interpret the monitored parameters.*

11. MONITORING AND WARNING SIGNS

- **Parameters to monitor at each visit**
  - body weight (an increase of more than 2 kg in 1–3 days suggests fluid and salt retention);
  - heart rate and blood pressure, pre- and post-exercise;
  - Borg scale score at the reference exercise level, compared to previous sessions;
  - symptoms of congestion (dyspnea, edema) or low cardiac output (dizziness, marked fatigue).

Table 159. Signs of decompensation of heart failure

Sign	Meaning
Rapid weight gain	Early fluid and salt retention
Worsening dyspnea or new-onset orthopnea	Possible worsening pulmonary congestion
New or worsening edema	Systemic fluid and salt retention
Hypotension or new-onset arrhythmias on exertion	Possible hemodynamic instability

- **Emergency protocol**
  - Immediately stop the exercise when the alarm sounds;
  - Move the patient to a safe location and assess vital signs;
  - Immediately notify the coordinating physician;
  - Fully document the event after stabilization.

- **Escalation Protocol**

Any combination of the above signs requires postponing—not merely shortening—the exercise session and promptly informing the coordinating physician; the program may resume only after documented clinical stabilization, not based on subjective improvement reported by the patient.

Table 160. Escalation protocol based on the severity of warning signs

Severity Level	Example	Management
Mild	Mild weight gain, no other signs	Continue monitoring, document the episode
Moderate	Worsening dyspnea, new edema	Interrupt the session, prompt clinical evaluation
Severe	Symptomatic hypotension, new-onset arrhythmia	Activate the emergency protocol

- **The role of telemonitoring in patients with an implantable device**

In patients with CRT or another device capable of telemonitoring, automatically transmitted data can provide additional information about thoracic impedance (a surrogate for volume status) or arrhythmias occurring between visits; this information must be actively correlated with the progress of the rehabilitation program and not treated separately by the exercise team.

Practical Note: *In patients with HF, an exercise session should be postponed—not merely reduced in intensity—in the presence of any sign of decompensation, regardless of whether it is labeled as "acute" or, according to current terminology, "decompensated."*

Summary: *Monitoring patients with HF combines simple clinical parameters (weight, signs of congestion) with a clear escalation protocol, and in patients with implantable devices, telemonitoring can provide an additional layer of information—complementary to, not a substitute for, direct clinical assessment.*

12. PSYCHOLOGICAL AND COGNITIVE ASPECTS

- **Anxiety and Depression in Heart Failure**

Depression and anxiety are common in patients with HF, with a significantly higher prevalence than in the general population, and are associated with reduced adherence to treatment and rehabilitation programs, as well as a poorer prognosis; for this reason, active screening should be systematically included in the evaluation.

- **Cognitive Impairment Associated with Advanced Heart Failure**

In patients with advanced HF, particularly those with repeated episodes of decompensation, mild-to-moderate cognitive deficits are common—likely related to chronic cerebral hypoperfusion—and may impair the ability to follow and retain recommendations from the rehabilitation program, necessitating simplified and repeated therapeutic education.

- **Family support and adherence**

Involving a family member in the educational process—especially for patients with cognitive deficits or multiple comorbidities—improves early recognition of warning signs at home and supports long-term adherence to the rehabilitation program.

- **The teach-back technique in patient education**

The teach-back technique—asking the patient to restate, in their own words, the information provided (for example, warning signs that require contacting the medical team)—allows for rapid verification of correct understanding and is particularly useful for patients with mild cognitive impairments, which are common in advanced heart failure.

Summary: *The psychological and cognitive impact of heart failure, which is often underestimated, requires active screening and a tailored educational approach that involves the family, especially in patients with advanced forms of the disease or with repeated episodes of decompensation.*

13. CASE STUDIES

- **Case 1**

A 62-year-old male patient with HFrEF (EF 32%) of ischemic etiology, 6 weeks post-CABG, NYHA Class II, on full heart failure medication. Cardiopulmonary exercise testing showed a peak VO2 of 16 ml/kg/min and a ventilatory threshold at 85 bpm.

Requirements

1. Determine the risk category based on the information presented above
2. Specify the mechanical precautions still in place, considering the date of the procedure.
3. Develop the initial exercise prescription.

- **Case 2**

A 74-year-old female patient with HFpEF, obesity (BMI 34 kg/m²), permanent atrial fibrillation, and type 2 diabetes. Her medical history includes dyspnea on moderate exertion, with no recent decompensations.

Requirements

1. Discuss the role of comorbidities in this patient's functional limitations.
2. Propose an integrated therapeutic approach (exercise + other relevant interventions).
3. List the specific warning signs to monitor.

Practical Note: *Both cases illustrate the central principle of this manual: the phenotype (HFrEF/HFpEF) guides the general principles, but the individual context—surgical in the first case, comorbid in the second—essentially determines the actual specifics of the treatment plan.*

- **Case 3**

A 55-year-old patient with HFrEF (EF 28%) who underwent a heart transplant 4 months ago, is asymptomatic, and eager to resume the intense physical activity he engaged in prior to the transplant.

Requirements

1. Explain why the classically calculated target heart rate is not applicable to this patient.
2. Suggest the most appropriate method for determining exercise intensity.
3. List the atypical warning signs that the team should monitor for.

- **Case 4**

An 80-year-old female patient with HFpEF and a clinical frailty score of 6/9, 2 weeks after hospitalization for decompensation; currently stable but with reduced mobility and requiring assistance with activities of daily living.

Requirements

1. Discuss whether and how the program's goals should be adjusted in light of frailty.
2. Propose a session structure tailored to this patient profile.
3. List the specific monitoring elements for a patient who has recently experienced decompensation.

GUIDELINES FOR SOLVING THE CASE

- **Case 1**
  - Risk category: moderate, given a peak VO2 of 16 ml/kg/min and recent postoperative status (6 weeks);
  - Active precautions: sternal, up to 6–8 weeks post-CABG, so still partially active;
  - prescription: intensity below the ventilatory threshold (85 bpm), short sessions initially, without arm loading.

- **Case 2**
  - Comorbidities (obesity, AF, diabetes) contribute significantly to dyspnea, possibly more so than isolated diastolic dysfunction;
  - Integrated approach: weight management, monitoring of AF rhythm control during exercise, monitoring of blood glucose levels;

    - Signs to monitor: blood pressure response, irregular heart rate with symptoms, signs of hypoglycemia.

- **Case 3**
    - The classic target heart rate is unreliable due to post-transplant cardiac denervation;
    - Assessment using the Borg scale, with prolonged warm-up and gradual progression;
    - Atypical signs: marked dyspnea or unusual fatigue, in the absence of typical chest pain.

- **Case 4**
    - Realistic goals: maintaining functional autonomy, not necessarily a significant improvement in aerobic capacity;
    - Adapted program: low intensity, emphasis on strength and balance exercises, short sessions;
    - Monitoring: daily weight, signs of recurrent congestion, exercise tolerance.

14. NUTRITION IN PATIENTS WITH HEART FAILURE

- **Sodium Restriction—How Much and How**

Moderate sodium restriction (approximately less than 5 g of salt per day) remains a reasonable measure for preventing fluid and salt retention, although recent evidence suggests that very severe restriction offers no additional benefits and may negatively affect overall nutritional intake; therefore, the recommendation should be individualized rather than rigidly applied to all patients.

- **Cardiac cachexia and sarcopenic obesity**

Cardiac cachexia—significant unintentional weight loss associated with advanced heart failure—is a marker of poor prognosis and requires active caloric and protein support, not restriction, a principle opposite to that applied in obese patients. Sarcopenic obesity, discussed in other materials in this course, is also relevant in patients with HFpEF, for whom GIP/GLP-1 agonists are now recommended (Class IIa) in the presence of associated obesity.

- **Iron Deficiency—Screening and Functional Relevance**

Iron deficiency, even in the absence of anemia, contributes to reduced exercise capacity in patients with heart failure, and correcting it (often through intravenous iron administration in patients with heart failure and documented deficiency) improves functional capacity and quality of life; for this reason, screening (ferritin, transferrin saturation) should be systematically included in the initial evaluation.

- **Protein Intake and the Prevention of Sarcopenia**

In patients with heart failure, particularly the elderly or those at risk for sarcopenia, an adequate protein intake (approximately 1.0–1.2 g/kg body weight/day, adjusted for renal function) is recommended to maintain muscle mass, in conjunction with resistance training—a principle that holds true even in the context of a sodium-restricted diet.

- **The Mediterranean Diet**

Although evidence specific to HF is more limited than that for general cardiovascular prevention, the Mediterranean diet remains a reasonable recommendation for patients with HF, provided it is adapted to sodium restriction and, if necessary, to the increased caloric needs of cachectic patients.

Summary: *Nutritional management in patients with HF must be individualized: moderate, not severe, sodium restriction; caloric and protein support for cachectic patients; and active screening for iron deficiency, which is correctable and has a documented functional impact.*

15. CARDIOLOGY AND ONCOLOGY AND TREATMENT-INDUCED HEART FAILURE

- **Cardiotoxicity Associated with Cancer Treatments**

An increasingly large proportion of patients referred for cardiovascular rehabilitation due to heart failure comes from the population of cancer survivors treated with cardiotoxic therapies—anthracyclines, anti-HER2 therapies, tyrosine kinase inhibitors, and thoracic radiation therapy—which can cause ventricular dysfunction, sometimes years after the completion of cancer treatment.

- **Specifics of Assessment and Rehabilitation**

The evaluation of these patients must take into account both their current cardiovascular status and their oncological status (type of treatment, time since the last course of treatment, and associated hematologic risk). Moderate-intensity aerobic exercise is generally well tolerated and recommended, with documented benefits for cardiac function and for fatigue associated with cancer treatment; however, it should be adjusted based on current hematologic values.

Practical Note: *For patients currently undergoing active cancer treatment, hematologic values should be checked before initiating or continuing an exercise program, in collaboration with the oncology team.*

Summary: *Cancer treatment-induced heart failure is an emerging field that requires close collaboration between cardiology and oncology, with the exercise program tailored to the patient's current hematologic and oncologic status.*

16. ETHICAL ISSUES IN ADVANCED HEART FAILURE

- **Joint Physician-Patient Decision-Making at Stage D**

For patients with advanced heart failure (Stage D) who are refractory to standard treatment, decisions regarding the intensity of interventions—including participation in a rehabilitation program—must be made through a shared decision-making process that integrates a realistic prognosis, the patient's preferences, and quality-of-life goals, not merely the available technical options.

- **Palliative Care and Rehabilitation—Complementarity, Not Exclusivity**

Even for patients receiving palliative care, components of a rehabilitation program—such as light maintenance exercises and education on symptom management—can contribute to quality of life, a principle that contradicts the sometimes implicit notion that rehabilitation and palliative care are mutually exclusive.

Summary: *For patients with advanced heart failure, decisions regarding the intensity and goals of the rehabilitation program must be tailored to the individual through a shared decision-making process, recognizing that elements of rehabilitation may remain relevant even in a palliative care setting.*

Appendix 1. Expanded Initial Assessment Form

Table 145 . Expanded Initial Assessment Form for Patients with Heart Failure

Section	Items to be completed
General Information	Age, sex, primary diagnosis, date of event/procedure
Phenotype and stage	HFrEF/HFpEF, ESC stage (A–D), NYHA class
Echocardiographic parameters	EF, volumes, diastolic assessment
Biomarkers and laboratory tests	NT-proBNP/BNP, renal function, iron status, HbA1c
Exercise testing	Peak VO_2, ventilatory threshold
Comorbidities	
Current treatment	FMT, AMT, diuretics, anticoagulation
Individual Goals	Discussed and agreed upon with the patient

Appendix 2. Detailed Monitoring Form for the Drill Session

Table 146 . Detailed Monitoring Form for the Drill Session

Parameter	Pre-exercise	Peak exertion	Recovery (2 min)
Heart rate	___ bpm	___ bpm	___ bpm
Blood pressure	___/___ mmHg	___/___ mmHg	___/___ mmHg
Borg Scale	—	___/20	—
Body weight (daily, at home)	___ kg	—	—
Reported symptoms	—	_____	_____

Practical note: *Body weight should be checked daily at home by the patient, not just during exercise sessions, to enable early detection of fluid retention between scheduled visits.*

Appendix 3. Pre-session checklist for patients with heart failure

Table147 . Pre-session checklist for patients with heart failure

Check	Confirmed (Yes/No)
Today's body weight compared to yesterday's (increase <2 kg)	___
Absence of new signs of congestion (dyspnea, edema)	___
Diuretic therapy has not been changed recently without informing the team	___
The patient reports no new symptoms since the previous visit	___
The unit's emergency equipment is available	___

Practical note: *Any "No" answer to one of these checks must result in postponing the session and clarifying the situation with the coordinating physician before resuming the program.*

ABBREVIATIONS

Table 164. Glossary of Abbreviations – Chapter V

Abbreviation	Meaning
%Peak HR	Percentage of maximum heart rate (theoretical or achieved during the test)
1RM	One-Repetition Maximum – the maximum weight that can be lifted once (One-Repetition Maximum)
6MWT	6-Minute Walk Test
ACEI	Angiotensin-Converting Enzyme
AMT	Additional Medical Therapy (ESC 2026 Guidelines)
ARB	*Angiotensin Receptor Blocker*
ARNI	Angiotensin Receptor-Neprilysin Inhibitor
BB	Beta-blockers
BMI	Body Mass Index
BNP / NT-proBNP	B-type natriuretic peptide / N-terminal fragment of pro-BNP
BORG	Borg Scale for Subjective Perception of Exertion (6–20 or 0–10)
BP	Blood pressure
CABG	Coronary Artery Bypass Grafting – aortocoronary bypass
COPD	Chronic obstructive pulmonary disease
CPET	Cardiopulmonary exercise test
CRT	Cardiac Resynchronization Therapy
CRT-D	Cardiac resynchronization therapy with defibrillator function
EF	Ejection fraction
ESC	European Society of Cardiology
FITT-VP	The **ACSM** (*American College of Sports Medicine*) Guidelines for Prescribing Exercise
FMT	Foundational Medical Therapy (ESC 2026 Guidelines): in HFrEF—BB, ACEI/ARNI/BRA, ARM, SGLT2i
GDIT	Guideline-Directed Interventional Therapy
GDMT	Guideline-Directed Medical Therapy – FMT + AMT (i.e., all medication treatments recommended by the guidelines)
GLP-1	Glucagon-Like Peptide-1 – glucagon-like peptide-1
HF	Heart failure
HFmrEF	Heart failure with mildly reduced ejection fraction (EF 41–49%) – category removed from the 2026 ESC guidelines
HFpEF	Heart failure with preserved ejection fraction (EF ≥50%)
HFrEF	Heart failure with reduced ejection fraction (EF <50%, according to ESC 2026)
HIIT	High-Intensity Interval Training
HR	Heart rate
HRR	Reserve heart rate (Peak HR − Resting HR; Karvonen formula)

Abbreviation	Meaning
ICD	Implantable Cardioverter-Defibrillator – implantable cardiac defibrillator
KCCQ	Kansas City Cardiomyopathy Questionnaire
LVAD	Left Ventricular Assist Device
LVEF	Left ventricular ejection fraction
MET	Metabolic Equivalent of Task – metabolic equivalent (1 MET ≈ 3.5 mL O_2/kg/min)
MICT	Moderate-Intensity Continuous Training
MLHFQ	Minnesota Living with Heart Failure Questionnaire – the Minnesota questionnaire on living with heart failure
MRA	*Mineralocorticoid Receptor Antagonist*
MV	Minute ventilation
NYHA	New York Heart Association – Functional Classification of Heart Failure
Peak HR	Peak heart rate – the maximum heart rate reached during exercise
RER	Respiratory Exchange Ratio (VCO2/VO2)
RPE	Rating of Perceived Exertion – subjective perception of exertion
SGLT2	Sodium-Glucose Cotransporter 2 – sodium-glucose cotransporter type 2
SGLT2i	Sodium-glucose cotransporter 2 inhibitors (iSGLT2)
SpO_2	Peripheral oxygen saturation
VCO_2	Carbon dioxide production
VE/VCO_2	Slope of the CO_2 ventilatory equivalent—an indicator of ventilatory efficiency
VO_2	Oxygen consumption
VO_2 peak	Peak oxygen consumption—the highest value reached during exercise (peak VO_2)
VO_2max	Maximum oxygen consumption (at plateau)
VT1	First ventilatory threshold (aerobic/anaerobic threshold)
VT2	Second ventilatory threshold (respiratory compensation point)

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