Cardiac risk stratification in cardiac rehabilitation programs: a review of protocols

Estratificação de risco cardíaco em programas de reabilitação cardíaca: revisão de protocolos

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Abstract

Objective: Gather and describe general characteristics of different protocols of risk stratification for cardiac patients undergoing exercise.

Methods: We conducted searches in LILACS, IBECS, MEDLINE, Cochrane Library, and SciELO electronic databases, using the following descriptors: Cardiovascular Disease, Rehabilitation Centers, Practice Guideline, Exercise and Risk Stratification in the past 20 years.

Results: Were selected eight studies addressing methods of risk stratification in patients undergoing exercise.

Conclusion: None of the methods described could cover every situation the patient can be subjected to; however, they are essential to exercise prescription.

Descriptors: Cardiovascular Diseases. Rehabilitation Centers. Practice Guideline. Exercise. Risk Assessment.

Resumo

Objetivo: Reunir e descrever características gerais dos diferentes protocolos de estratificação de risco existentes para cardiopatas submetidos ao exercício.

Métodos: Realizou-se busca nas bases eletrônicas LILACS, IBECS, MEDLINE, Biblioteca Cochrane, SciELO, por meio dos descritores: Doenças cardiovasculares, Centros de Reabilitação, Guia de Prática Clínica, Exercício e Estratificação de Risco e a palavra-chave "Risk Stratification", nos últimos 20 anos.

Resultados: Foram selecionados oito trabalhos abordando métodos de estratificação de risco em indivíduos submetidos a exercício.

Conclusão: Nenhum dos métodos descritos conseguiu abranger todas as situações de risco a que o paciente está sujeito, porém eles são fundamentais para prescrição do exercício.

Descritores: Doenças Cardiovasculares. Centros de Reabilitação. Guia de Prática Clínica. Exercício. Medição de Risco.

INTRODUCTION

Cardiovascular diseases (CVD) are currently the leading cause of mortality worldwide, generating significant economic costs to the health system[1,2]. In Brazil, they are responsible for about 20% of all deaths in individuals over 30 years-old[3] and ischemic heart disease, strokes, hypertension and other heart diseases are responsible for 16 million deaths annually[4].

This scenario points to the need for effective low-cost interventions of a preventive nature to reduce cardiovascular events and improve survival in patients with CVD[5]. In this

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Abbreviations, acronyms & symbols	
AACVPR	American Association of Cardiovascular and Pulmonary Rehabilitation
ACSM	American College of Sports Medicine
AHA	American Heart Association
BSC	Brazilian Society of Cardiology
CR	Cardiac rehabilitation
CVD	Cardiovascular diseases
HRF	Heart rate frequency
METs	Metabolic equivalent
SFC	Société Française de Cardiologie

context, programs for cardiac rehabilitation (CR) emerge as a major tool because studies show that the practice of physical exercise safely improves aerobic capacity, cardiovascular function, and quality of life of cardiac patients[6,7].

In addition, regular physical exercise may, among other effects, promote benefits of a psychological nature, improve levels of adherence to pharmacological therapy[8], control risk factors, contribute to the reduction in mortality and improve symptoms of CVD[9], reducing clinical manifestations such as acute myocardial infarction, cardiac arrest or sudden death[10] and favorably influencing surgical outcomes[11].

However, to obtain the beneficial effects and ensure safety during physical exercises it is essential that it be prescribed correctly. To prescribe the appropriate exercise intensity for each individual it is first necessary to know the patient's level of risk, and for this purpose cardiac risk stratification becomes critical.

Cardiac risk stratification means careful evaluation of the clinical and functional status of the patient, starting with clinical history and physical, laboratory and ancillary tests, in order to classify the subject individually in a risk range (low, moderate, and high)[12]. This procedure provides indications for the appropriate targeting of the patient throughout the rehabilitation process, and the identification of risk levels, making it an integral part of the management of patients during and after an acute myocardial event[13].

In recent years, different protocols for cardiac risk stratification for participation in exercise programs were developed and validated by several national and international entities, such as multivariate analyzes, which have provided clinicians and researchers with a wide range of information and, consequently, a reduction in the probability of acute cardiovascular events occuring while performing an exercise program[12,14].

Despite the importance of this process of risk stratification in physical exercise programs for cardiac patients, to our knowledge there are no publications that gather information and describe the characteristics of different protocols. Thus, this study aimed to gather information and describe the general characteristics of different existing risk stratification protocols, which may assist researchers and clinicians in targeting safer

behaviors and interventions in physical exercise programs for cardiac patients.

METHODS

Search strategy

This study was constructed from a survey of data found in existing literature. We conducted a literature search to update ourselves on methods for cardiac risk stratification in patients undergoing exercise, without language restrictions.

The articles selected were obtained through a literature search conducted in December 2013 in the following online databases: LILACS, IBECS, MEDLINE, the Cochrane Library and SciELO, covering the last 20 years, i.e. from January 1993 to December 2013. For this research cross-references were made of the following keywords in English (MeSH - Medical Subject Headings): Cardiovascular Diseases, Rehabilitation Centers, and Exercise Practice Guideline. The keyword "Risk Stratification" was also included because of its extreme relevance to the topic under focus.

Selection of studies

For this review, we initially carried out the screening of titles related to the topic in question. This selection was based first on titles that addressed the main idea: cardiovascular rehabilitation, cardiovascular diseases, physical training, safety in physical training for cardiac patients, cardiovascular events, cardiac risk, and methods of cardiac risk stratification; then, on titles that focused on activities to combat sedentary lifestyle. At the end of the search, repeated titles were removed, since they were held in various databases.

Then, a detailed reading of the article abstracts was undertaken to select only those that dealt exclusively with CR and the methods used for cardiac risk stratification for performing exercise. Having excluded abstracts that did not deal with the issue, the full texts were evaluated and those did not meet the exclusion criteria were included in the final results of the search. In addition, all references to the studies selected were reviewed to supplement the search. A single evaluator, under the supervision of a senior reviewer, undertook all stages of the search.

Inclusion criteria

The inclusion criteria were the following: a) studies published in all languages; b) the latest update of the stratification method, when updates occur periodically; c) articles published in the past 20 years; and d) works that specifically addressed strategies for cardiac risk assessment in cardiac patients undergoing exercise.

Exclusion Criteria

The exclusion criteria were the following: a) studies that did not mention the need for risk stratification in individuals

practicing CR; b) authors who quoted in their work methods previously published by other entities; c) works in which risk assessment only covered risk factors for CVD; d) publications that dealt only with the prescription of exercise without describing a method for risk stratification; e) those articles that did not contain all the information found in the abstract; and f) full articles that were impossible to obtain for analysis after direct contact with the author or co-author.

Analysis of Data

Data were described according to the methods of risk stratification performed, references used for the development of the protocol, the clinical condition of the patient, the population addressed, and summary of the test protocol.

RESULTS

Eight methods of risk stratification were extracted from the databases searched. The general characteristics of the protocols found can be seen in Chart 1.

Protocol of the American College of Sports Medicine[14]

The guidelines of the American College of Sports Medicine (ACSM) for assessment and prescription of exertion were drawn up taking into account the participation of any person in an exercise program[14]. Thus, the main feature of the criteria for risk stratification of this entity is its simplicity (Chart 2). The presence of features in a higher risk class determines the range of risk and intensity of the training of each individual. Moreover, according to the guidelines, the presence of a negative risk factor (high serum HDL cholesterol) eliminates a positive risk factor so that an individual being rated in the moderate risk by having three positive risk factors may be reclassified in the low risk range if high serum HDL cholesterol is present. This highlights the importance of investigating laboratory tests, clinical and family history, and conducting physical assessments to determine the range of appropriate risk for each individual.

ACSM does not delimit the period in which the individual must be reassessed. However, the use of this protocol alone requires extreme caution in patients with heart disease whose clinical condition has become unstable[14].

Chart 1. General characteristics of the methods of risk stratification.

Protocol	General Characteristics	Classification
ACSM (2007)	Targeted at any individual who wants to perform an exercise program. Uses the presence of risk factors, signs and symptoms of cardiovascular, metabolic, and respiratory diseases as risk selection criteria. it does not discuss results of additional tests for stratification.	Low, moderate and High Risk.
SBC (2013)	Targeted at those who have suffered AMI and it uses the maximal exercise test as a primary method of risk stratification. It also uses the presence of signs and symptoms of congestive heart failure in high-risk individuals. It considers as high risk those individuals with functional capacity = 5 METs and EF = 35%.	Low, moderate and High Risk.
AHA (2001)	Extensive method that uses mainly symptoms or the presence of heart disease, risk factors, and exercise testing for risk selection. It considers as high risk those individuals with functional capacity <6 METs and EF ≤ 30%.	Risk Classes (A, B, C and D).
PASHKOW (1993)	Targeted at those who have suffered AMI. It uses results of complementary tests to stratify risk. It considers as high risk for events those individuals with functional capacity ≤ 4.5 METs. It does not use EF as criteria.	Low, moderate and High Risk.
AACVPR (2007)	It uses the maximal exercise test as the primary method of risk stratification (presence of symptoms during stress or recovery test). Their absence may inappropriately categorize the individual. Targeted at those who have suffered AMI. It considers as high risk those individuals with functional capacity <5 METs and EF <40%.	Low, moderate and High Risk.
SFC (2002)	Targeted at those who have suffered AMI based mainly on clinical history and maximal exercise test. It considers at high-risk individuals with functional capacity <5 METs and EF <30%.	Low, moderate and High Risk.
SEC (2000)	Designed for individuals who have suffered AMI. It uses clinical data and tests such as echocardiography and exercise testing to define risk groups. It considers as high risk those individuals with functional capacity <5 METs and EF <35%.	Low, moderate and High Risk.
SEC (2000)	Designed for individuals who have suffered AMI and wish to participate in sports activities. It evaluates VO$_2$max associated with age to designate METs value in low-risk individuals. It considers as high risk those individuals with EF <50%.	Low and High Risk.

SBC: Brazilian Society of Cardiology; ACSM: American College of Sports Medicine; AHA: American Heart Association; AACVPR: American Association of Cardiovascular and Pulmonary Rehabilitation; SFC: French Society of Cardiology; SEC: Spanish Society of Cardiology; METs: Metabolic Equivalent; EF: Ejection Fraction; CHF: Congestive Heart Failure; AMI : Acute Myocardial Infarction; VO$_2$Max: Maximum Oxygen Consumption

Chart 2. ACSM criteria for risk stratification of events during the year.

Low Risk
- Men under 45 years of age and women under age 55 who are asymptomatic and do not meet more than a threshold of major risk (Positive factors - family history, cigarette smoking, hypertension, hypercholesterolemia, impaired fasting glucose, obesity, sedentary lifestyle. Negative factors - high serum HDL cholesterol).

Moderate Risk
- Men aged 45 years or older, women aged 55 or more; or those who satisfy the threshold for two or more major risk factors described above.

High Risk
- Individuals with one or more signs and symptoms (pain; discomfort in the chest, neck, jaw or arms; breathlessness at rest or on rapid exertion; dizziness or syncope, orthopnea or paroxysmal nocturnal dyspnea; edema of the ankles, palpitations or tachycardia intermittent claudication; known heart murmur; excessive fatigue; breathlessness in daily activities) or cardiovascular disease (heart disease, cerebrovascular, peripheral vascular), lung disease (chronic obstructive pulmonary disease, asthma, interstitial lung disease, cystic fibrosis) or known metabolic disease (diabetes mellitus, thyroid disorders, kidney or liver disease).

Thus, the objective of this protocol is to identify the need to refer an individual at increased risk for a medical evaluation and possibly undergo an exercise test. The ACSM itself recognizes the guidelines of the AACVPR and the AHA and recommends that heart patients be stratified based on the criteria of those institutions[14].

Protocol of the Brazilian Society of Cardiology[15]

The protocol of the Brazilian Society of Cardiology (BSC) is mainly based on results obtained with the maximal exercise test. According to BSC, it is essential to carry out the progressive maximal exercise test to identify myocardial ischemia, ventricular dysfunction, cardiac arrhythmias and atrioventricular conduction disorders. Based on the results obtained in the supplementary examination patients should be stratified to start a cardiac rehabilitation program[15]. Chart 3 shows the criteria used by BSC for risk stratification.

According to BSC, patients referred to as low risk should be reassessed every year, whereas patients with moderate and high risk should be reassessed earlier, that is, every six months or whenever any clinical modification occurs[15].

The presence of any of the characteristics listed in the moderate or high classifications is sufficient for classification of patients in that category.

Protocol of the American Heart Association[16]

The American Heart Association (AHA) developed a more extensive system of risk classification for the medical release of cardiac patients, described in Chart 4A and 4B.

The AHA guidelines provide recommendations for the monitoring and supervision of participants and/or patients as well as for possible restriction of activities[16]. Unlike previous guidelines, AHA classifies individuals into risk classes (A, B, C and D), and within the B and C classes there are further criteria that determine the clinical characteristics and the presence of symptoms that characterize the evolution of Congestive Heart Failure, pinpointed by the "Functional Classification of the New York Heart Association." If the individual chooses not to undergo a stress test, he should follow the guidelines described in Class B.

Individuals classified in Class A (Chart 4A) have no restrictions except for basic advice, with supervision and monitoring during exercise deemed unnecessary. It is suggested that people classified as Class A-2 and, in particular, class A-3 undergo a medical examination and possibly an exercise stress test under medical supervision before starting vigorous exercise[16].

Chart 3. SBC criteria for risk stratification of events during the year.

Low Risk
- Functional Capacity = 7 METs.
- Absence of myocardial ischemia at rest or stress test with less than 6 METs intensity.
- Left ventricular EF = 50%.
- Absence of significant ventricular ectopy after the third day after AMI.
- Adequate blood pressure response to stress.
- Ability to self-monitor the intensity with which one exercises

Moderate Risk
- Presence of myocardial ischemia.
- ST depression = 2 mm segment.
- Reversible abnormalities during exercise, myocardial scintigraphy with thallium.
- Left ventricular EF = 35-49%.
- Absence of complex ventricular ectopy.
- No drop in blood pressure during exercise.

High Risk
- Recurring angina with ischemic changes in ST segment beyond 24 hours after hospital admission.
- Signs and symptoms of congestive heart failure.
- Left ventricular EF = 35%.
- Complex ventricular ectopy (multifocal premature ventricular contractions, ventricular tachycardia, R on T phenomenon, ventricular fibrillation).
- Functional Capacity = 5 METs in angina limited exertion test, ST segment depression or inadequate blood pressure response.
- Decreased or failure to increase systolic blood pressure during exercise.
- Persistent ischemic changes in ST and/or angina during exercise.

METs: metabolic equivalent; EF: ejection fraction; AMI: Acute Myocardial Infarction

Chart 4A. AHA criteria for risk stratification of events during exercise in healthy individuals (class A) and low risk (class B).

Class A
This classification includes:
- A1: Children, adolescents, men < 45 years old, and women < 55 years old who have no symptoms or known presence of heart disease or major coronary risk factors.
- A2: Men ≥ 45 years old and women ≥ 55 years old who have no symptoms or known presence of heart disease and with < 2 major cardiovascular risk factors.
- A3: Men ≥ 45 years old and women ≥ 55 years old who have no symptoms or known presence of heart disease and with ≥ 2 major cardiovascular risk factors.

Class B
This classification includes individuals with any of the following diagnoses:
- B1: CAD (MI, CABG, PTCA, angina pectoris, abnormal exercise test, and abnormal coronary angiograms) whose condition is stable and who have the clinical characteristics outlined below.
- B2: Valvular heart disease, excluding severe valvular stenosis or regurgitation with the clinical characteristics outlined below.
- B3: Congenital heart disease; risk stratification for patients with congenital heart disease should be guided by the 27th Bethesda Conference recommendations*.
- B4: Cardiomyopathy: EF ≤ 30%; includes stable patients with heart failure with clinical characteristics as outlined below, excluding hypertrophic cardiomyopathy or recent myocarditis.
- B5: Exercise test abnormalities that do not meet any of the high risk criteria outlined in class C below.

Clinical characteristics (must include all of the following)
Clinical characteristics according to additional tests. They should check all the clinical features present.
1. New York Heart Association class 1 or 2
2. Exercise capacity ≤ 6 METs
3. No evidence of congestive heart failure
4. No evidence of myocardial ischemia or angina at rest or on the exercise test at or below 6 METs
5. Appropriate rise in systolic blood pressure during exercise
6. Absence of sustained or nonsustained ventricular tachycardia at rest or with exercise
7. Ability to satisfactorily self-monitor intensity of activity

*Fuster V, Gotto AM, Libby P. 27th Bethesda Conference: Matching the intensity of risk factor management with the hazard for coronary disease events. J Am Coll Cardiol 1996;27:964-76.

EF: ejection fraction; CAD: Coronary Artery Disease; MI: Myocardial Infarction; CABG: coronary artery bypass graft; PTCA: Percutaneous Transluminal Coronary; METs: Metabolic Equivalent

Chart 4B. AHA criteria for risk stratification of events during exercise in individuals with moderate to high risk (class C) and activity restriction (class D).

Class C
This classification includes individuals with any of the following diagnoses:
- C1: CAD with the clinical characteristics outlined below.
- C2: Valvular heart disease, excluding severe valvular stenosis or regurgitation with the clinical characteristics outlined below.
- C3: Congenital heart disease; risk stratification for patients with congenital heart disease should be guided by the 27th Bethesda Conference recommendations*.
- C4: Cardiomyopathy: EF 30%; includes stable patients with heart failure with the clinical characteristics outlined below, excluding hypertrophic cardiomyopathy or recent myocarditis.
- C5: Complex ventricular arrhythmias not well controlled.

Clinical characteristics (any of the following):
1. NYHA class 3 or 4.
2. Exercise test results
- Exercise capacity 6 of METs
- Angina or ischemic ST depression at a workload of 6 METs
- Fall in systolic blood pressure below resting levels during exercise
- Nonsustained ventricular tachycardia with exercise
3. Previous episode of primary cardiac arrest (ie, cardiac arrest that did not occur in the presence of an acute myocardial infarction or during a cardiac procedure).
4. A medical problem that the physician believes may be life-threatening.

Class D
This classification includes individuals with any of the following:
- D1: Unstable ischemia.
- D2: Severe and symptomatic valvular stenosis or regurgitation.
- D3: Congenital heart disease; criteria for risk that would prohibit exercise conditioning in patients with congenital heart disease should be guided by the 27th Bethesda Conference recommendations*.
- D4: Heart failure that is not compensated.
- D5: Uncontrolled arrhythmias.
- D6: Other medical conditions that could be aggravated by exercise.

*Fuster V, Gotto AM, Libby P, Loscalzo J, McGill HC. 27th Bethesda Conference: Matching the intensity of risk factor management with the hazard for coronary disease events. J Am Coll Cardiol 1996;27(5):964-76.

CAD: Coronary Artery Disease; EF: Ejection Fraction; NYHA: New York Heart Association; METs: Metabolic Equivalent

For those assigned to either Class B (Chart 4A) or C (Chart 4B), the guideline recommends that activities be individualized and prescribed by qualified persons. In addition, initial medical supervision is considered useful until such time when the individual can perform his or her activities safely and without supervision, usually between the 6th and 12th session, always accompanied by the monitoring of blood pressure and electrocardiogram[16].

After successfully completing a series of supervised exercise sessions in Class C, the patient may be reclassified to Class B, provided that it is safe to undertake that activity with the prescribed intensity and that he has demonstrated

the capacity for self-monitoring. No activity for the purpose of training is recommended for those classified in Class D (Chart 4B), but daily activities are prescribed, so that the individual may be gradually restored to Class C[16].

It should be recognized that the AHA guidelines do not take into account co-morbidities (for example, type 1 diabetes, morbid obesity, severe lung disease or debilitating neurological or orthopedic conditions) that could result in modification of recommendations for monitoring and supervision during exercise training[14].

Protocol designed by Frederic J. Pashkow[13]

In 1993, Pashkow developed a model for risk stratification based on the orientation of important guidelines at the time as well as new means of risk identification. He summarized them in three levels: low, moderate and high risk; considered by him to be extremely useful for the planning of the program[13].

His model is aimed at those who have suffered cardiac events such as myocardial infarction[13] and it uses important features of ancillary exams, such as the progressive exercise test, electrocardiogram, and echocardiogram.

The author argues that risk stratification should be a continuous process within or outside a rehabilitation program, since it evaluates the evolution of risk of each individual and determines the prognosis of any patient after an acute myocardial infarction. Moreover, the process of stratification makes it possible to identify individuals at risk of death or reinfarction and those who require only conventional therapy to achieve a good prognosis, such as those considered low risk[13].

The low, moderate and high risk levels suggested by Pashkow are described in Chart 5. The presence of a feature in the highest risk range classifies the individual in that category.

Protocol of the American Association of Cardiovascular and Pulmonary Rehabilitation[12]

The guideline of the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) uses variables common to those established models and allows for categorization in simple classes of risk, divided into: low, moderate, and high risk for participating in exercises. The low-risk patients do not exhibit any of the characteristics mentioned. Patients at greatest risk have any one of the characteristics mentioned. Those who do not fit into any classification are considered moderate risk[12].

This guidance is based primarily on the findings of an exercise test. It states that those who do not undergo the test before entering the program or those with undiagnosed exercise testing may be categorized inadequately using these criteria, and it suggests that these patients should be treated more cautiously with regard to risk stratification and that they should be monitored with a more conservative methodology for the prescription of exercise[12]. Chart 6 describes the definitions of low, moderate and high risk suggested by the AACVPR guideline.

Chart 5. Criteria defined by Pashkow for risk stratification of events during the year.

Low Risk
- After uncomplicated coronary revascularization
- ≥ 7.5 METs 3 weeks after an ischemic event
- No ischemia, left ventricular dysfunction or significant arrhythmia

Moderate Risk
- ≤ 7.5 METs 3 weeks after an ischemic event
- Angina or 1 - to 2- mm ST segment depression with exercise
- Perfusion or wall motion abnormalities with stress
- History of congestive heart failure
- More than mild but less than severe left ventricular dysfunction
- Late potentials present on signal-averaged electrocardiogram
- Nonsustained venricular arrhythmia
- Inability to self-monitor exercise or comply with exercise prescription

High Risk
- Severe left ventricular dysfunction
- ≤ 4.5 METs 3 weeks after cardiac event
- Exercise-induced hypotension (≥ 15 mmHg)
- Exercise-induced ischemia > 2-mm ST segment depression
- Ischemia induced at lows levels of exercise
- Persistence of ischemia after exercise
- Sustained ventricular arrhythmia spontaneous or induced

METs: Metabolic Equivalent

For individuals classified as low-risk for participating in exercise, the guideline recommends that direct supervision of the exercise should occur for at least 6-18 workouts or 30 days after the event or post-procedure. For those with moderate risk, direct supervision should occur for at least 12 to 24 sessions or 60 days after the event or post-procedure, and high-risk patients should be monitored for at least 18 to 36 exercise sessions or 90 days after the event or post-procedure[12].

Protocol of the Société Française de Cardiologie[17]

The Société Française de Cardiologie (SFC) adapted the recommendations on exercise prescription of the European Society of Cardiology and the AACVPR in preparing its method of risk stratification[17]. This model is based on the patient's history and clinical examination and, systematically, on the stress test and echocardiogram[17]. This protocol recommends that after the initial assessment, the patient may be included in one of three risk categories described in Chart 7. However, the SFC suggests as an initial and temporary contraindication those who present: pericardial effusion, phlebitis, thrombus in the left ventricle or decompensated heart failure[17].

According to the SFC, patients with low or intermediate risk are able to start a classical training program, the structure of which is currently based primarily on the training heart rate frequency (HRF) determined during the stress test[18].

Chart 6. AACVPR criteria for risk stratification in patients with low, moderate and high risk of events during the year.

Low Risk
- Absence of complex ventricular dysrhythmia during exercise testing and recovery
- Absence of angina or other significant symptoms (e.g., unusual shortness of breath, light-headedness, or dizziness heart rate and systolic blood pressure with increasing workloads and recovery)
- Presence of normal hemodynamics during exercise testing and recovery (i.e., appropriate increases and decreases in heart rate and systolic blood pressure with increasing workloads and recovery)
- Functional capacity ≥ 7 METs

Nonexercise testing findings
- EF ≥ 50% at rest
- Uncomplicated MI or revascularization procedure
- Absence of complicated ventricular arrhythmias at rest
- Absence of CHF
- Absence of signs or symptoms of post-event or post-procedure ischemia
- Absence of clinical depression

Nonexercise testing findings
- EF ≥ 50% at rest
- Uncomplicated MI or revascularization procedure
- Absence of complicated ventricular arrhythmias at rest
- Absence of CHF
- Absence of signs or symptoms of post-event or post-procedure ischemia
- Absence of clinical depression

Moderate Risk
- Presence of angina or other significant symptoms (e.g., unusual shortness of breath, light headedness, or dizziness occurring only at high levels of exertion [<7METs])
- Mild to moderate level of silent ischemia during exercise testing or recovery (ST-segment depression < 2 mm from baseline)
- Function capacity < 5 METs

Nonexercise testing findings:
- EF = 40% to 49% at rest

High Risk
- Presence of complex ventricular arrhythmias during exercise testing or recovery
- Presence of angina or other significant symptoms (e.g., unusual shortness of breath, light-headedness, or dizziness at low levels of exertion [≥ 5 METs] or during recovery)
- High level of silent ischemia (ST-segment depression ≥ 2 mm from baseline) during exercise testing or recovery
- Presence of abnormal hemodynamics with exercise testing (i.e., chronotropic incompetence or flat or decreasing systolic BP with increasing workloads) or recovery (i.e., severe postexercise hypotension)

Nonexercise testing findings:
- EF < 40% at rest
- History of cardiac arrest or sudden death
- Complex dysrhythmias at rest
- Complicated MI or revascularization procedure
- Presence of CHF
- Presence of signs or symptoms of postevent or postprocedure ischemia
- Presence of clinical depression

METs : Metabolic Equivalent; EF: Ejection Fraction; MI: Myocardial Infarction; CHF: Congestive Heart Failure; BP: Blood Pressure

High-risk patients, combined with indicators of poor prognosis (low ejection fraction, early and severe ischemia, serious ventricular arrhythmias) are patients for whom training poses greater risks, but, on the other hand, gains are high in terms of quality of life. The prescription of exercise is more cautious here, and it usually begins with mild sessions and a higher level of monitoring during the first days, allowing for adaptation and subsequent resistance training[18].

Protocol of the Sociedad Española de Cardiología[19,20]
The Spanish Society of Cardiology (ESC) published two papers in 2000, entitled: *Guides to clinical practice in cardiovascular prevention and cardiac rehabilitation*[19] and *Guides to clinical practice in physical activity of the cardiac patient*[20], which addressed the practice of physical activity in individuals who have suffered AMI. The guide provides recommendations for risk stratification of these individuals using criteria such as

clinical assessment and examinations, including echocardiography and stress testing. Although the guidelines are similar, there are differences in the stratification of risk.

The article entitled "Guides to clinical practice in cardiovascular prevention and cardiac rehabilitation"[19] suggests that the main indication for CR is ischemic heart disease in its different aspects, but it is expandable to all CVD and should also be applied to healthy subjects presenting risk factors. The guide reports that a program of secondary prevention should always be associated with CR in order to favor control of risk factors, improve quality of life, and reduce mortality and morbidity in this population[19]. The guide stratifies cardiac patients in three risk categories (Chart 8A) and calls for supervised programs for individuals of medium and high risk, with controlled heart failure, and those with psychological manifestations such as depression. Those classified as low risk for cardiac events during exercise can be admitted to a supervised program if they present the conditions mentioned[19].

The article entitled "Guides to clinical practice concerning the physical activity of cardiac patients"[20] makes general recommendations regarding the practice of sports for cardiac patients. The guide stresses that before starting any physical activity, whether of a sporting nature or not, cardiac individuals should be evaluated as to their personal and family medical history as well as sports activities they have engaged in and should undergo physical assessments, including a 12-lead resting electrocardiogram and stress test to at least submaximal[20]. The guide recommends avoiding exercise in patients with unstable angina, heart failure and aortic aneurysm or severe ventricular pseudoaneurysm. It stratifies individuals into two risk classes[20].

Chart 8B refers to the risk stratification for patients undertaking sports. Some similarities with Chart 8A can be noticed: both advise that individuals should be considered low risk when presenting ejection fraction >50%, absence of arrhythmias and ischemia, and clinical hospital outcome without complications. However, when the stratification refers to cardiac patients with high risk, most of the characteristics of a group considered "moderate" are added to the criteria that describe a high-risk population, allocating to this risk range all those individuals who would be considered as moderate risk or high risk in the previous guide.

It is still recommended that patients at low risk should be assessed annually and they may play sports with low to moderate dynamic and static component. Those at high risk should be reassessed every six months and they are free to

Chart 7. SFC criteria for risk stratification of events during the year.

Low Risk
- Hospital clinical evolution without complications (without recurrent ischemia, heart failure or severe ventricular arrhythmia).
- Good functional capacity (>6 METs) three weeks or more after the acute phase.
- Systolic function of the left ventricle preserved.
- Absence of myocardial ischemia at rest or during exercise.
- Absence of serious ventricular arrhythmias at rest or during exercise.

Moderate Risk
- Moderate functional capacity (5-6 METs) three weeks or more after the acute phase, high ischemic threshold.
- Moderately impaired systolic function of the left ventricle.
- Moderate residual myocardial ischemia and/or depression of the ST <2 mm segment in the stress test or reversible myocardial ischemia during echocardiography or isotopic explorations.
- Mild ventricular arrhythmias (Lown class I or II) at rest or during exercise.

High Risk
- Evolution of hospital clinical complications (heart failure, cardiogenic shock and/or severe ventricular arrhythmia).
- Survivors of sudden death.
- Low functional capacity (<5 METs) three weeks or more after the acute phase.
- Severely impaired left ventricular function (EF <30%).
- Residual myocardial ischemia (severe incapacitating exertion angina, low ischemic threshold and/or ST-segment depression >2 mm on the electrocardiogram in exercise).
- Complex ventricular arrhythmias (Lown Class III, IV, and V) at rest from exercise.

METs: Metabolic Equivalent; EF: Ejection Fraction

Chart 8A. ESC criteria for risk stratification of events during the year to participate in a cardiac rehabilitation program.

Low Risk
- Hospital clinical evolution without complications
- Functional capacity >7 METs
- Absence of ischemia
- EF >50%
- Absence of severe ventricular arrhythmias

Moderate Risk
- Occurrence of Angina
- Abnormalities reversible with thallium stress
- Functional capacity between 5-7 METs
- EF 35-49%

High Risk
- Reinfarction. Hospital CHF
- ST segment depression of >2 mm with HR <135 bpm
- Functional capacity <5 METs with or without ST-segment depression
- EF <35%
- Hypotensive response to stress
- Malignant ventricular arrhythmias

METs: Metabolic Equivalent; EF: Ejection Fraction; CHF: Congestive Heart Failure

Chart 8B. ESC criteria for risk stratification of events during the year for participants in sports activities.

Low Risk
- Systolic function normal at rest (EF greater than 50%).
- Normal tolerance to exercise.
- Patients under 50 years old: greater than 35 ml/min kg (10 METs) VO_2max
- Patients between 50 and 59 years old: greater than 31 ml/min kg (9 METs) VO_2max
- Patients between 60 and 69 years old: greater than 28 ml/min kg (8 METs) VO_2max
- Patients over 70 years old: VO_2max greater than 24 ml/min kg (7 METs)
- Absence of exercise-induced ischemia.
- Absence of exercise-induced arrhythmias.
- Absence of coronary stenosis or greater than 50%, indicating good coronary revascularization.

Moderate Risk
Does not mention

High Risk
- Depressed systolic function at rest (EF less than 50%).
- Evidence of exercise-induced ischemia.
- Evidence of exercise-induced arrhythmias.
- Coronary lesions exceeding 50% stenotis.

EF: Ejection Fraction; VO_2max: Maximum Oxygen Consumption; METs: Metabolic Equivalent

participate in low intensity sports. For those patients who have had a heart attack or bypass surgery recently, it is advised to join a CR program before starting any sports activity. Finally, the guide points out that patients with ischemic heart disease should not compete, and are only free to practice sports to stay healthy[20].

CONCLUSION

The criteria for risk stratification for events during exercise or physical activity are derived from multivariate research considering factors associated with the increased risk of morbidity and mortality in general.

The main protocols for cardiac risk stratification for participation in physical exercise programs that are currently available are organized by the following entities: the American College of Sports Medicine (ACSM), the Brazilian Society of Cardiology (SBC), the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR), the American Heart Association (AHA), the Société Française de Cardiologie (SFC) and the Spanish Society of Cardiology (SEC).

These entities regularly publish reviews of their guidelines for assessment and prescription of exertion, trying to establish standards for the assessment and prescription of exertion, including the recommendations for risk stratification of patients who wish to begin a rehabilitation program.

In addition to these entities, Pashkow developed a method of stratification aimed at those with episodes of myocardial infarction, based on current guidelines at the time and on new means of identifying risks and he summed it up into low, medium, and high risk[12].

Most protocols use additional tests as reference, among which the ergometric test can be considered as a well-established methodology for risk stratification of cardiac patients[21]. For cardiac risk stratification the metabolic equivalent (METs) obtained from the ergometric test is indicated in many of the protocols as one of the main references for determining the risk level of each individual. The METs is a unit used to quantify the intensity of physical activity and energy expenditure caused by it[12].

The objective of stratifying cardiac risk goes beyond the classification of the individual's risk as it also allows the clinician to direct the therapeutic approach, to establish the level of monitoring and the appropriate dose of exercise (intensity, duration, etc.). Therefore, it is very important to implement risk stratification both for those who want to start a program of self-directed physical activity and for those who enter programs with exercises for primary or secondary prevention.

Among the protocols found for cardiac risk stratification with the exception of ACSM, all the protocols use the findings of the stress test as the main reference to stratify an individual safely, before starting exercise training, making this an extremely important tool in a CR program. Those using data from stress testing determine that the individual at greatest risk is one that presents a METs value lower than 5 METs during the test, and moderate values between 5 and 7.5 METs, enabling greater safety when choosing any of protocols, since there is no exaggerated disproportion in them.

However, only the ACSM protocol uses comorbidities such as type 1 diabetes, morbid obesity, severe pulmonary disease, and neurological conditions as stratifying criteria, which are important for planning the training as well as for a better view of the patient's condition and response to exercise.

SFC and AACVPR are the only ones that address the factor of "cardiac arrest" as a criterion to determine wheter a patient is at high risk for cardiac events during exercise, a very relevant factor when seeking to admit an individual safely into a rehabilitation program.

The SEC issued two stratification methods for cardiac patients, one for those who underwent CR and another for those who wish to practice sports competitively[19,20]. Like other entities it stratifies risks based on clinical findings and laboratory tests such as echocardiogram and stress test. For those individuals who wish to practice sports activities the criteria are more stringent when establishing the ranges of risk, because it involves a much more intense activity than that performed in a CR center.

Of all the methods mentioned here, only the ACSM is not directly aimed at patients suffering from a cardiovascular

disorder, which can make its use less safe when applied to this population.

In particular, the AHA protocol is further subdivided into four risk classes, those considered healthy, those at low-risk, those at moderate to high risk, and those for whom physical training is not recommended. The other protocols classify individuals as low, moderate, and high risk. We may note another difference between protocols regarding to how up-to-date they are, given that the oldest protocol dates from 1993 and the most recent from 2013.

When assessing whether the AACVPR and AHA guidelines are really valid when predicting complications during exercise, Paul-Labrador et al.[22] found that neither were effective in assigning patients with complications to high-risk groups demonstrated by the low positive predictive values (5-7% variation) and low sensitivities (17-42% variation). However, the authors noted that these results might not be a specific failure of the guidelines, but might rather be due to the combination of an absence of potential predictors of risk and the low occurrence of serious complications in their study.

On the other hand, Zoghbi et al.[23], when evaluating the proposed AACVPR protocol in 1999 associated with non-cardiac comorbidities[24], such as diabetes mellitus, chronic obstructive pulmonary disease, cerebrovascular disease, and peripheral arterial disease, among others, observed that cardiac events were best predicted when both classifications were combined, suggesting that in order to appreciate more fully the overall complexity of the disease among patients practicing CR, risk stratification should be supplemented not only with the inclusion of cardiac risk factors, as suggested in current guidelines, but also with an evaluation of non-cardiac comorbidities[25].

When stratifying the cardiac risk patients attending 65 CR centers by using the SFC protocol , Pavy et al.[26] were unable to correctly predict the risk of complications during physical training. The same occurred with Vongvanich et al.[27] when they used the AACVPR protocol. The authors attribute this result to the low frequency of serious complications during the trainings conducted.

We are not aware of studies evaluating other protocols (ACSM, SBC, and Pashkow SEC). Finally, based on the studies cited above, although risk stratification remains necessary at the beginning of a rehabilitation program, the occurrence of a major cardiovascular event seems to be difficult to predict in most cases[22-27].

Several guidelines allow risk stratification, but the criteria are derived from factors associated with an increased risk of morbidity and mortality in the general population[12]. Thus, it is not clear whether the overall risk and the risk during exercise training are similar[26].

Finally, to prescribe the appropriate exercise intensity within a CR program, it is necessary to know beforehand the level of risk that each individual faces. This stratification of cardiac risk associated with the assessment of non-cardiac comorbidities and cardiac risk factors for CVD is absolutely paramount because that way it is possible to establish the level of monitoring and the appropriate dose of exercise and consequently, it is essential for the start of a safe and effective CR program.

Authors' roles & responsibilities	
AKFS	Analysis and/or interpretation of data; final approval of the manuscript; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content
MPCRB	Analysis and/ or interpretation of data; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content
AFBB	Analysis and/or interpretation of data; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content
FMV	Analysis and/or interpretation of data; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content
FLP	Analysis and/or interpretation of data; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content
LCMV	Analysis and/or interpretation of data; final approval of the manuscript; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for content

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