REVIEW ARTICLE

# Exercise Programs in Patients with Coronary Artery Disease and/or Myocardial Infarction: A Review of Systematic Reviews

*Programas de ejercicio físico en pacientes con enfermedad de las arterias coronarias y/o infarto de miocardio: Una revisión de revisiones sistemáticas*

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## ABSTRACT

**Background:** The aim of this study was to determine the influence of exercise programs and how they are prescribed (frequency, intensity, type and time) on the variables of cardiac rehabilitation in patients with coronary artery disease or myocardial infarction. We conducted a review of systematic reviews and meta-analyses through a search in PubMed y Web of Science of the articles published until February 1, 2020. Of 3902 articles identified, 19 were selected. The quality of the studies included was evaluated with A Measurement Tool to Assess Systematic Reviews 2. The quality of the studies was moderate-high. Exercise programs (strength training, high-intensity interval training, moderate intensity continuous training and Tai Chi) were beneficial for cardiac rehabilitation of patients with coronary artery disease or myocardial infarction. We present evidence of the best way of prescribing two exercise training programs.

**Keywords:** Coronary artery disease - Myocardial infarction - Exercise - Cardiac rehabilitation - Exercise therapy

## RESUMEN

**Introducción:** El objetivo de este estudio fue conocer la influencia de programas de ejercicio físico y sus características de prescripción (frecuencia, intensidad, tipo y tiempo) sobre variables de la rehabilitación cardíaca en pacientes con enfermedad coronaria y/o infarto de miocardio. Realizamos una revisión de revisiones sistemáticas y metaanálisis en PubMed y Web of Science, con artículos publicados hasta el 1 de febrero de 2020. Se identificaron un total de 3902 artículos, de los cuales se seleccionaron 19. Se utilizó *'A Measurement Tool to Assess Systematic Reviews 2'* para evaluar la calidad de los estudios incluidos. Dieciséis estudios poseían una calidad moderada-alta. Programas de ejercicio físico (i.e. entrenamiento de fuerza, entrenamiento por intervalos de alta intensidad, entrenamiento continuo de moderada intensidad y taichí) resultaron beneficiosos en la rehabilitación cardíaca de pacientes con enfermedad de las arterias coronarias y/o infarto de miocardio. Además, se encontró evidencia sobre los mejores rangos de las características de prescripción del entrenamiento para dos programas de ejercicio físico.

**Palabras claves:** Enfermedad de las arterias coronarias - Infarto de miocardio - Ejercicio - Rehabilitación cardíaca - Terapia con ejercicio

## INTRODUCTION

Coronary artery disease (CAD) affects 17.5 million people each year, (1) being the leading cause of death worldwide and is expected to reach 9.2 million deaths by 2030. (2) Each year, more than 7 million people have a myocardial infarction (MI) with a risk of death of 10% and a risk of a second MI of 20%. (3) The current prevalence and mortality rate of CAD or MI are expected to increase in the following years and represent a major social and health care problem. (2,3)

Cardiac rehabilitation (CR) is a tool for the treatment and secondary prevention of cardiovascular diseases. (4,5) CR should include exercise training for its success. (6) In fact, exercise-based CR reduces cardiovascular mortality and hospital admissions in patients with CAD or MI. (6) For this reason, exercise-based CR programs are crucial to reduce these events and improve patients' health. (4)

Exercise-based CR programs are the major elements for secondary prevention in patients with CAD or MI, but there is no consensus about which types of exercise provide the greatest benefits and are the most

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adequate for this population. (7) Therefore, the key is to identify the different possibilities of exercise training programs and which provide the greatest benefits for CR. For this purpose, exercise training should be described in detail, which implies the delimitation of 4 components that are essential to measure the effects of training: frequency, intensity, type and time (FITT) of exercise prescription. (8) The components of the FITT principle constitute the exercise dose, prescription or quantity needed to improve health. (9) According to the American College of Sports Medicine, the hazard of cardiovascular events may more likely be reduced by careful attention to a safe and effective exercise prescription that addresses the FITT principle according to disease stage and status. (8) Several frequencies, intensities, types and times of exercise have been proposed in CR. (10)

The components of the FITT principle of aerobic moderate-intensity continuous training (MICT) and other types of exercise training still require systematic analysis to provide clinically relevant information about the pathophysiology of recovery in this population. There is a need to understand which combination of the components of the FITT principle is the most efficient for improving cardiovascular adaptations to exercise training in this population. (11)

The scientific literature is full of different types of training with limited analyses of the effects of the components of the FITT principles on CR. Therefore, the aim of the present study is to identify which exercise training program and components of the FITT principle are the most effective and beneficial on the variables of CR for patients with CAD or MI.

## METHODS

This systematic review was performed following the recommendations of The Cochrane Collaboration Handbook. (12) This approach is recommended to summarize, synthesize, and compare the results of systematic reviews of research to provide relevant evidence to clinical decision makers. (12) Because of significant heterogeneity within the systematic reviews included, we did not assess pooled effects and we provide primarily descriptive results.

### Search strategy

An electronic search of reviews published until February 1, 2020, was conducted using PubMed and Web of Science (WOS) databases. We included systematic reviews or metanalyses evaluating the effects of exercise programs and their FITT principle on CR of persons with CAD or MI.

In WOS, the search was conducted with keywords to define disease, intervention, language of the study and type of article: coronary artery disease' OR 'myocardial infarction' AND 'exercise' OR 'exercise therapy' OR 'exercise training programs' OR 'exercise rehabilitation' OR 'physical training' OR 'exercise training' OR 'exercise protocol' OR 'exercise prescription' OR 'cardiac rehabilitation' AND 'English' OR 'Spanish' AND 'review'.

In PubMed, the MeSH (Medical Subject Heading) terms were used to define cardiovascular disease and intervention with exercise therapy. The combination used was: 'coronary artery disease' [MeSH] OR 'myocardial infarction' [MeSH] AND 'exercise' [MeSH] OR 'exercise therapy' [MeSH] OR 'cardiac rehabilitation' [MeSH]. The search was restricted to MeSH as a major topic in all the cases. The search criteria included full text systematic reviews and/or meta-analyses of human studies published in English or Spanish.

Inclusion and exclusion criteria

The selected articles had to meet the following inclusion criteria: (1) studies had to evaluate exercise-based CR programs in people with CAD or MI; (2) with analysis of the effect of those programs on secondary prevention of coronary artery disease; (3) articles had to be published in full text in English or Spanish, in the selected databases; and (4) they had to be systematic reviews or meta-analyses.

Exclusion criteria included: (1) studies on patients with cardiovascular disease other than CAD or MI; (2) reviews without reports of the specific results of exercise programs on CAD or MI; (3) studies that did not specify or analyze at least one of the components of the FITT principle on exercise prescription; (4) reviews with results of CAD or MI combined with another condition; and (5) articles based on animal studies.

### Identification of studies

After combining the results obtained in both databases following the search strategy, 3902 articles were identified; once duplicate records were eliminated, 3316 were screened (Fig. 1). Based on the inclusion/exclusion criteria, two reviewers (BBP and VDG) performed the following screening procedure: (1) title and abstract screening; (2) full text review and eligibility assessment of the articles selected after the previous step. Disagreements were resolved by a third reviewer. Figure 1 shows the flow diagram of the search process according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. (13)

### Data collection

Two reviewers (BBP and VDG) collected the data which included: type of study, objectives, years of search, inclusion criteria, number of interventions included in the systematic review and/or meta-analysis, characteristics of exercise training (frequency/duration, intensity, type and time), results on the variables analyzed and conclusions (Table S1). The different variables analyzed in the studies included are shown in Table S2.

### Assessment of study quality

Methodological quality was assessed using the Assessment of Multiple Systematic Reviews 2 (AMSTAR-2) tool, a validated critical appraisal tool for systematic reviews that include randomized or non-randomized trials. (14) AMSTAR-2 is questionnaire with 16 domains with options of answer: "yes" (positive result), "partial yes" (partial adherence to the standard), or "no" (the standard was was not achieved). (14) The instrument has 7 critical domains that can significantly affect the validity of a review and its conclusions, and 9 non-critical domains (Table 1). According to the weakness detected, four levels of confidence are possible: high (no or one non-critical weakness); moderate (no critical weakness and more than one non-critical weakness), low (one critical flaw with or without non-critical weaknesses) and critically low (more than one critical flaw with or without non-critical weaknesses). (14) Confidence for each study was evaluated using the AMSTAR-2 checklist. (15) Each review included was evaluated by two reviewers who discussed the evaluations and reached consensus. Table 1 summarizes the assessment of study quality of the different systematic reviews or meta-analyses included.

## RESULTS

### Characteristics of the studies included

A total of 19 studies were included (Figure 1). Table 1 indicates the levels of confidence according to AMSTAR-2. The overall quality of the studies included was moderate-high. Of the 19 studies, the level of confidence was high in 8, moderate in 8, low in 2 and critically low in 1.

The studies included are summarized in Table S1. Three studies are systematic reviews and 16 are systematic reviews with meta-analyses. Six studies evaluated patients with CAD (18,19,21,22,27,33), 2 patients with MI (18,32) and 11 included both conditions (16,17,34,20,23,25,26,28–31).

All the studies analyzed the effects of exercise training on the variables of CR for adult patients (age range: 48-79 years). Fifteen studies evaluated the effects of exercise on the components of physical condition (16,17,27,28,30,31,33,19–26), 7 studies evaluated the effects on cardiovascular risk factors (20,22,24,25,28,29,33), while psychosocial components were evaluated in 4 studies (16,20–22), cardiac function in 4 (18,22,32,34) and cardiorespiratory parameters in 3 (22,23,29) (Table S2). In addition, 3 studies analyzed the effects of exercise training on mortality (21,24,32), 2 on adverse cardiovascular events (21,24) and 1 on healthcare costs. (21)

Type of exercise training: 2 studies compared strength training (alone or combined with MICT) with MICT (26,30), 1 study included only strength training (31), 1 study focused on eccentric exercise (27), 6 studies compared high intensity interval training (HIIT) with MICT (16, 17,22,25,28,33), 1 study included HIIT and MICT without comparing them (32),

**Table 1.** Assessment of the methodological quality (AMSTAR-2) of the studies included

| Studies | Domains/Items 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | LC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gomes-Neto (2015) (16) | Yes | P/Y | Yes | P/Y | Yes | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | P/Y | Yes | H |
| Hannan (2018) (17) | Yes | Yes | Yes | Yes | Yes | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | H |
| Haykowsky (2011) (18) | Yes | P/Y | Yes | P/Y | Yes | Yes | P/Y | Yes | P/Y | No | Yes | Yes | Yes | Yes | P/Y | Yes | H |
| Kraal (2011) (19) | Yes | Yes | Yes | P/Y | Yes | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | H |
| Liu (2018) (20) | Yes | P/Y | Yes | P/Y | Yes | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | P/Y | Yes | H |
| Long (2018) (21) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | N/A | Yes | H |
| Pattyn (2018) (22) | Yes | P/Y | Yes | P/Y | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | H |
| Yang (2018) (23) | Yes | Yes | Yes | Yes | Yes | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | N/A | Yes | H |
| Cramer (2015) (24) | Yes | P/Y | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | N/A | N/A | Yes | Yes | N/A | Yes | M |
| Elliott (2014) (25) | Yes | P/Y | Yes | P/Y | No | No | P/Y | Yes | Yes | No | Yes | No | Yes | Yes | N/A | Yes | M |
| Hollings (2017) (26) | Yes | Yes | Yes | P/Y | No | No | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | P/Y | Yes | M |
| Karagiannis (2016) (27) | Yes | P/Y | Yes | P/Y | Yes | No | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | N/A | Yes | M |
| Liou (2016) (28) | Yes | P/Y | Yes | P/Y | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | No | M |
| Snoek (2013) (29) | Yes | P/Y | Yes | P/Y | Yes | Yes | Yes | P/Y | Yes | No | N/A | N/A | Yes | Yes | N/A | Yes | M |
| Valkeinen (2010) (30) | Yes | P/Y | Yes | P/Y | No | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | P/Y | No | M |
| Yamamoto (2016) (31) | Yes | P/Y | Yes | P/Y | Yes | No | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | M |
| Lawler (2011) (32) | Yes | P/Y | Yes | No | No | Yes | P/Y | P/Y | P/Y | No | Yes | Yes | Yes | Yes | Yes | Yes | L |
| Pattyn (2014) (33) | Yes | P/Y | Yes | No | No | Yes | P/Y | Yes | Yes | No | Yes | Yes | Yes | Yes | N/A | Yes | L |
| Oliveira (2014) (34) | Yes | P/Y | Yes | P/Y | Yes | Yes | P/Y | Yes | No | No | N/A | N/A | No | P/Y | N/A | Yes | CL |

H: high; L: low; CL: critically low; M: moderate; LC: level of confidence.
AMSTAR-2 has 7 critical domains (items 2, 4, 7, 9, 11, 13, 15) and 9 non-critical domains that may be answered as "yes", "partial yes" (P/Y), 2no" or "not applicable" (N/A): 1. Did the research questions and inclusion criteria for the review include the components of PICO? 2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol? 3. Did the review authors explain their selection of the study designs for inclusion in the review? 4. Did the review authors use a comprehensive literature search strategy? 5. Did the review authors perform study selection in duplicate? 6. Did the review authors perform data extraction in duplicate? 7. Did the review authors provide a list of excluded studies and justify the exclusions? 8. Did the review authors describe the included studies in adequate detail? 9. Did the review authors use a satisfactory technique for assessing the risk of bias in individual studies that were included in the review? 10. Did the review authors report on the sources of funding for the studies included in the review? 11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results 12. If meta-analysis was performed, did the review authors assess the potential impact of risk of bias in individual studies on the results of the meta-analysis or other evidence synthesis? 13. Did the review authors account for risk of bias in individual studies when interpreting/ discussing the results of the review? 14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review? 15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias and discuss its likely impact on the results of the review? 16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

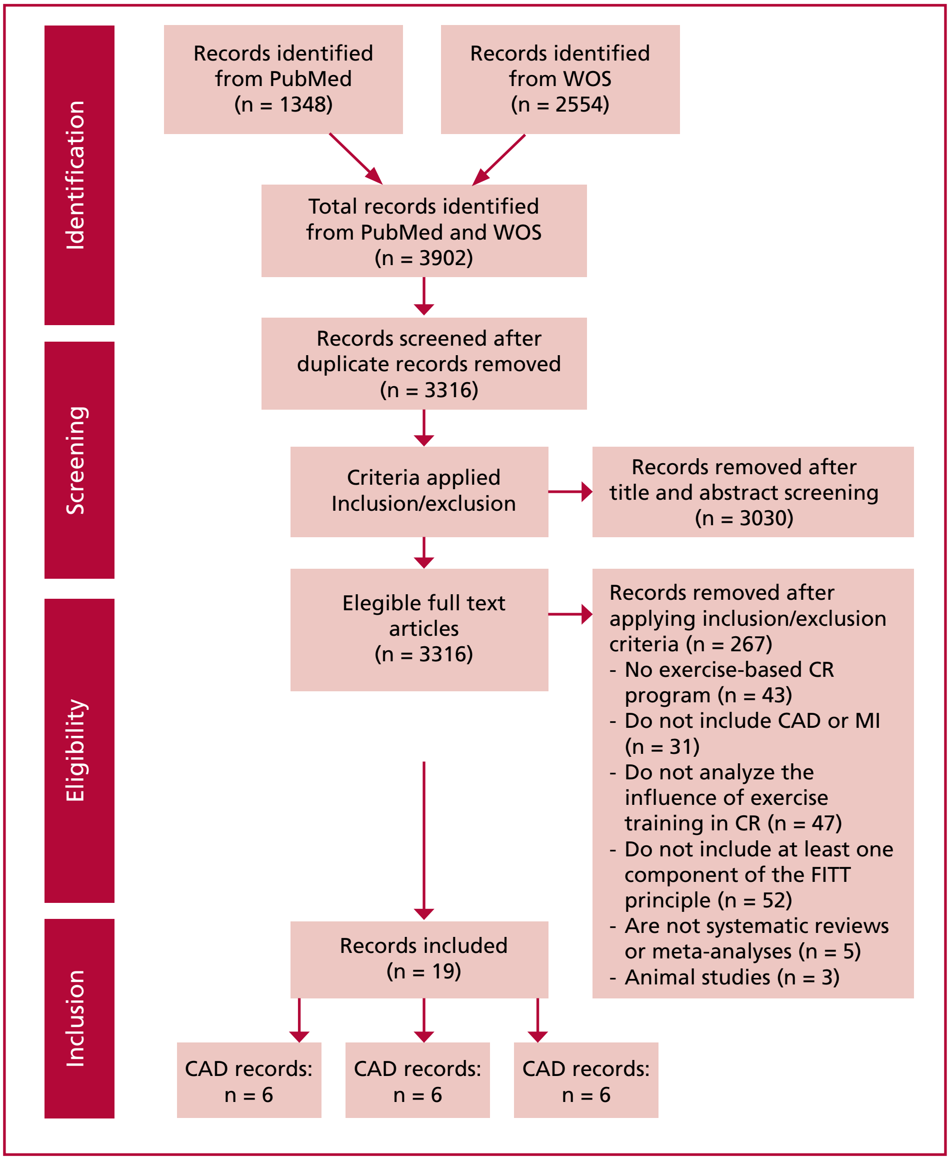


**Fig. 1.** Flow diagram for the search and selection processes of eligible systematic reviews and meta-analyses

CAD: coronary artery disease MI: myocardial infarction WOS: Web of Science
FITT: Frequency, intensity, type and time

5 focused exclusively on MICT (18,19,21,29,34), 2 analyzed the effects of Tai Chi (20,23), and 1 examined the influence of yoga (24) (Table S3).

Components of the FITT principle: 1 study analyzed the effects of frequency, (19) 6 evaluated exercise duration, (17–19,22,30,32) 2 studies examined the influence of intensity, (19,22), 1 compared the type of exercise training, (22) and 2 analyzed the effects of time. (12,22), All the studies analyzed the effects of the type of exercise training on the variables of CR (Table S4).

## Effects of exercise training by type of cardiovascular disease

### *Coronary artery disease*

Seventeen studies evaluated the effects of exercise training in patients with CAD (16,17,27–31,33,34,19–26). Exercise training improved anxiety, quality of life (20), aerobic capacity (16,17,20,22,25,26,28,30,31), depression (20), flow mediated dilation (22), left ventricular ejection fraction (22), peak heart rate (22), heart rate recovery (22,29), resting heart rate (22,28), muscular strength (26,31), blood lipids, blood glucose, oxygen uptake efficiency slope (22), ventilatory efficiency slope (22,23), body weight (22,28,33), first ventilatory threshold (22,33), oxygen pulse (22) and blood pressure (22).

### *Myocardial infarction*

Thirteen studies analyzed the effects of exercise training in patients with MI (16,17,31,32,34,18,20,23,25,26,28–30). Training improved anxiety, quality of life (20), aerobic capacity (16–18,20,25,26,28,30,31), depression (20), left ventricular ejection fraction (18), muscular strength (26,31), cardiac mortality, cardiovascular mortality, all-cause mortality, reinfarction, and end-systolic and end-diastolic volumes (18).

### Effects on the components of the FIIT principle

#### *Duration/frequency*

##### Duration

One high quality study analyzed the effects of HIIT and reported that programs of 7–12 weeks' duration produced greater improvement on aerobic capacity (peak O2 uptake [$VO_2$ peak]) than programs with duration < 6 weeks and > 12 weeks. Another high-quality study found that HIIT programs of < 12 weeks' duration had no significant difference on aerobic capacity ($VO_2$ peak) than longer programs (22). A low-quality study reported that HIIT programs lasting between 3 and 12 months did not improve mortality and reinfarction rates compared with training lasting between 1 and 3 months (32).

A moderate quality study evaluating MICT showed that intervention programs between 6 and 12 months obtained greater improvements in aerobic capacity (maximal O2 uptake, $VO_2$ max) than shorter training programs (30). One high-quality study reported that MICT programs that increased their duration from 2 to 28 weeks improved aerobic capacity (19). One high-quality study reported that MICT lasting 6 months produced greater improvements in left ventricular ejection fraction and end-systolic and end-diastolic volumes than those programs with a duration < 3 months (18). One low-quality study reported that MICT programs lasting between 3 and 12 months did not improve mortality and reinfarction rates compared with training lasting between 1 and 3 months (32).

In addition, one high-quality study showed that MICT starting within the first week after MI produced greater improvements in left ventricular ejection fraction and end-systolic and end-diastolic volumes compared with programs starting later (18). One moderate-quality study found that MICT starting within the first 12 weeks after a cardiovascular event (coronary angioplasty, coronary revascularization, MI, percutaneous transluminal coronary) resulted in greater improvement in aerobic capacity ($VO_2$ max) than training started later (30).

##### Frequency

One high-quality study compared the effect of MICT in 5 sessions per week versus 2 sessions per week and reported maximum improvements in $VO_2$ peak of 1.05 mL/kg/min and 0.42 mL/kg/min, respectively (19).

#### *Intensity*

One high-quality study reported maximum improvements of 4.82 mL/kg/min in $VO_2$ peak in MICT programs with an intensity of 79% of $VO_2$ peak compared with improvements of 2.74 mL/kg/min in programs with an intensity of 45% of $VO_2$ peak (19). One high-quality study observed that very HIIT (≥ 90% of peak HR; ≥ 85% of reserve HR; ≥ 80% of $VO_2$ peak) produced greater improvements in aerobic capacity ($VO_2$ peak) than high intensities (70-89% of peak HR; 60-84% of reserve HR; 60-79% of $VO_2$ peak), with no significant differences between subgroups (22).

#### *Type of exercise program*

Improvements on aerobic capacity with HIIT and MICT programs were reported by 3 high-quality, 2 moderate -quality and 1 low-quality studies, especially with HIIT (mean range: +1.25-1.78 mL/kg/min $VO_2$ peak) (16,17,22,25,28,33). In addition, in 1 high-quality study, HIIT produced greater improvements in peak HR compared with MICT (22). Rest HR (28) and body weight (28,35) improved with MICT versus HIIT. When HIIT was compared with MICT, there were no significant differences in flow mediated dilation, left ventricular ejection fraction, heart rate recovery, blood lipids, blood glucose, oxygen uptake efficiency slope, ventilatory efficiency slope, blood pressure, first ventilatory threshold and oxygen pulse (22).

High- and moderate-quality studies that exclusively analyzed the effects of MICT reported improvements on left ventricular ejection fraction (18), recovery HR (29) and end-systolic/end-diastolic volumes (18).

Two moderate-quality studies found improvements of strength training (alone or combined with MICT) on aerobic capacity (test duration, $VO_2$ max) and muscular strength (26,31). One moderate-quality study reported that strength training improved mobility in adults > 65 years (31). One high-quality study reported significant effects of Tai Chi in improving anxiety, quality of life, aerobic capacity (test duration and $VO_2$ max) and depression (20).

##### Type of exercise

A high-quality study evaluating HIIT (walking/running vs. cycling) did not find significant differences in the effects on aerobic capacity ($VO_2$ peak) (22).

#### *Time*

One high-quality study compared the effect of MICT with sessions lasting 45 minutes versus 20 minutes and reported maximum improvements in $VO_2$ peak of 5.62 mL/kg/min and 2,50 mL/kg/min, respectively (19). Another high-quality study analyzed different intervals (<1 min vs 1-3 min vs >4 min) of HIIT, without significant differences in the effects on aerobic capacity ($VO_2$ peak) (22).

## DISCUSSION

The aim of the present study is to identify the influence of exercise training and of components of the FITT principle on the different variables of CR in patients with CAD or MI. The main findings of this review were that exercise training (strength training, HITT, MICT and Tai Chi) improved aerobic capacity, left ventricular ejection fraction, HR recovery, resting HR, peak HR, muscular strength, mobility, body weight and end-systolic and end-diastolic volumes. The analysis of the components of the FITT principle revealed that the best results of CR programs were achieved with HIIT with a duration of 7-12 weeks and an intensity > 90% of peak HR and 80% of $VO_2$ peak, and with MICT performed with a frequency of 5 sessions per week, duration of 6-12 months, intensity of 79% of $VO_2$ peak, session of 45 minutes and early start between 1 and 12 weeks.

Exercise training according to the variables analyzed

HIIT and MICT produced significant improvements on aerobic capacity in patients with CAD or MI, but HIIT was more effective. Aerobic capacity is an important predictor of the prognosis and mortality of these diseases, and those exercise programs that improve aerobic capacity are essential in CR (16). $VO_2$ max and $VO_2$ peak were the measures of aerobic capacity most used and the main parameters to determine it (25,30). Improvements in $VO_2$ max and $VO_2$ peak values in HIIT programs range from 1.5-7.7 mL/kg/min (25,33) and from 0.4-5.2 mL/kg/min in MICT programs (19,25,30,33) in patients with CAD and/or MI. Improvements in $VO_2$ peak values in HIIT programs versus MICT programs range from 1,25-1.78 mL/kg/min in patients with CAD or MI (16,17,22,25,28,33). These improvements are clinically significant, as an increase on aerobic capacity > 3.5 mL/kg/min is associated with a 10-25% reduction in the risk of all-cause mortality (25,30). Other studies reported that improvements starting at 1 mL/kg/min reduced the risk of all-cause mortality and cardiovascular mortality by 15-17% in this population (33).

MICT was associated with improvements in resting HR (28) and body weight (28,33) compared with HIIT in patients with CAD or MI. Resting HR and body weight are important cardiovascular risk factors in this population (36,37). The higher percentage of body fat in obese patients with CAD is associated with increased risk of type 2 diabetes, hypertension, and adverse cardiovascular events such as stroke, all-cause mortality, or acute coronary syndrome (36,38). High resting HR is associated with coronary atherosclerosis and left ventricular dysfunction and greater risk of ventricular arrhythmias and myocardial ischemia (37). Improvements of resting HR and body weight achieved with MICT are due to higher energy expenditure associated with greater volume of exercise (33,39).

MICT improves left ventricular ejection fraction and end-systolic and end-diastolic volumes in patients with MI (18). Left ventricular remodeling is a strong predictor of cardiovascular mortality after MI (40). Previous studies have found favorable effects of MICT on left ventricular remodeling in patients with MI (41). MICT improves HR after 1 minute of recovery from exercise in patients with CAD or MI (29). Delay in HR recovery after exercise is a predictor of mortality in patients with CAD probably due to reduced vagal activity, pro-inflammatory response or endothelial dysfunction, increasing mortality in this population (42).

In addition, HITT was associated with greater improvements in peak HR, an important prognostic marker of CAD compared with MICT (22). Higher exercise intensities challenge the cardiac muscle more to provide the working muscles with oxygen, resulting in an increased stroke volume and HR (22).

Strength training (alone or combined with MICT) improved the aerobic capacity, muscular strength and mobility in patients with CAD or MI (26,31). Increased muscular strength is associated with better outcomes and survival of these conditions and improve mobility in elder patients with these diseases (44). Patients with low mobility have higher risk of cardiovascular events (31). Strength training may be crucial in CR in this population to improve these variables (44).

Further studies with appropriate methodology are necessary to associate eccentric training with Tai Chi and yoga with benefits on CR in this population (20,24,27)

### Components of the FITT principle

The aim of this synthesis of systematic reviews was to summarize the scientific evidence of exercise training programs and how they are prescribed in persons with CAD or MI. We have found a great variety in the parameters of the components of the FITT principle and a great variety of variables analyzed, isolated in a few cases, which complicate the task of reaching firm conclusions on the ideal prescription of exercise training for this population.

#### *Duration*

The studies included reported duration of training programs < 1 year (17-19,30,32), except for 1 study that compared exercise training < 1 year and > 1 year (22).

When HIIT programs were analyzed, the best results on CR were achieved with those programs lasting between 7 and 12 weeks in patients with CAD or MI (17). Previous studies have demonstrated that the maximum benefits on aerobic capacity in patients with CAD were achieved with HIIT programs between 6 and 12 weeks (45). However, these results could be due to the fact that HITT programs with longer duration did not present incremental and progressive workload included in the design of their training session (45). When MICT programs were analyzed, the best results on CR were achieved with those programs lasting between 6 and 12 months in patients with CAD or MI (18,19,30).

The beginning of training is another important element to consider in CR programs for patients with CAD or MI. Early start of exercise training (1-12 weeks) with MICT after a cardiovascular event has beneficial effects on CR (18,30). Most exercise-based CR programs start between 4 and 6 weeks after hospital discharge, even though exercise training is safe in the first week after MI (46).

### *Frequency*

MICT programs with a frequency of 5 sessions per week achieved better results than those of 2 sessions per week (19). This is consistent with the most efficient prescription of MICT in CR programs in this population according to the American Heart Association, which recommends exercising 5 days a week (47).

### *Intensity*

For MICT, the best benefits on aerobic capacity was achieved with exercise intensity of 79% versus 45% of $VO_2$ peak in patients with CAD (19). Previous studies also found improvements on aerobic capacity when the intensity of MICT increased from 50 to 85% of $VO_2$ peak in this population (48). Aerobic interval training was found to be more beneficial compared with aerobic continuous training in increasing $VO_2$ peak in patients with CAD (22). Previous studies have also reported that very HIIT (>92% of peak HR) produced better improvements on aerobic capacity compared with high intensity training (> 88% of peak HR) in this population (49). The intensity of HIIT is important for the efficacy of training on aerobic capacity (22).

### *Type*

The best HIIT protocol for CR of patients with CAD still remains unclear and the effectiveness of HIIT is similar independently of the type of exercise (walking/running vs. cycling) in this population (22).

### *Time*

For exercise training with MICT, the best benefits on aerobic capacity were achieved with sessions lasting 45 minutes compared with 20 minutes in patients with CAD (19). The American Heart Association recommends 30-60 minutes of MICT for CR programs (47). Therefore, CR programs sessions of MICT between 45 and up to 60 minutes produce the greatest benefits in this population. The duration of the high intensity interval does not improve the aerobic capacity (22). There is little evidence of the effect of this component of the FIT principle on secondary prevention in this population, and more studies are needed to clarify the influence of time on CR (50).

### *Main limitations*

The studies included in this review are the result of a search conducted in 2 databases and in 2 languages, with limitations of having excluded studies of interest from other databases.

A significant limitation of this review is the impossibility of pooling the results, performing meta-analyses and comparing according to the different characteristics of training.

The information presented in the systematic reviews and meta-analyses included demonstrates a great variety in the parameters of the training protocols, and high heterogeneity in the results and in the methodological quality of the studies. In addition, important aspects such as pharmacologic treatment, stage of disease, or age were not included in the analysis. These elements may contribute to the risk of bias, so the conclusions drawn in these sections should be taken with caution.

## CONCLUSIONS

Strength training, HIIT, MICT and Tai Chi improve the aerobic capacity in adult patients with CAD or MI. Each of the different modalities had advantages over the others for specific parameters, but overall HIIT was the most beneficial for aerobic capacity in patients with CAD or MI, and MICT had better results on left ventricular ejection fraction and ventricular volumes in patients with MI. Strength training demonstrated improvements on muscular strength and mobility in both diseases.

In patients with CAD or MI, HIIT for 7-12 weeks and MICT for 6-12 weeks starting early (1-12 weeks) showed the best results on CR. The specific values of duration, frequency, intensity and time previously discussed ensure better outcomes. Further studies are needed to reach consistent conclusions to identify the most beneficial prescription of exercise programs among strength training, eccentric training, Tai Chi and yoga in this population.

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