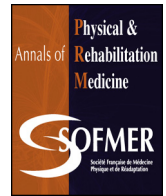




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Review

Eccentric exercise in ischemic cardiac patients and functional capacity: A systematic review and meta-analysis of randomized controlled trials

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ABSTRACT

Background: Eccentric (ECC) exercise is an “economical” type of exercise with low energy requirements and does not cause early fatigue. Therefore, it is used for cardiac patients, who have low physical activity and exercise intolerance, as an easier kind of training.

Objective: This systematic review aimed to investigate the efficacy of ECC exercise for functional capacity (FC) in patients with ischemic heart disease.

Design: Systematic review.

Methods: MEDLINE via PubMed and EBSCO databases were searched for articles of randomized controlled trials of adults with ischemic heart disease who underwent ECC training as compared with other forms of exercise (concentric exercise) or no exercise and assessed FC. The methodologic quality of studies was assessed by the PEDro scale. A meta-analysis was performed with sufficient homogeneity between at least 2 studies in the pre-defined comparisons.

Results: Four studies, investigating a total of 99 subjects, met the inclusion criteria. The results of the studies did not clearly indicate whether ECC exercise could improve FC better than traditional forms of exercise. However, the small number of studies and their methodologic weaknesses do not allow for drawing firm conclusions.

Conclusions: We found contradictory results about the effectiveness of ECC as compared with concentric exercise in terms of FC in ischemic cardiac patients. Further investigation with well-designed randomized trials is needed to determine the effectiveness of this kind of exercise for FC in such patients.

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1. Introduction

Functional capacity (FC) is the ability to perform daily activities [1]. In most cardiac patients, FC is reduced with the occurrence of cardiac symptoms such as early fatigue, dyspnea and angina pectoris during activities [2]. Moreover, the progressive skeletal muscle wasting and weakness increase functional limitations in patients with chronic heart failure [3,4]. Therefore, ischemic cardiac patients became functionally disabled, because many patients (e.g. New York Heart Association class-IV patients) are unable to perform any physical activity without discomfort, and symptoms are present even during rest [2].

Ischemic heart disease (IHD) is the primary cause of death worldwide according to the World Health Organization (WHO). Specifically WHO statistics show that 7.4 million people died because of IHD in 2012 [5]. IHD is the end effect of coronary artery disease (CAD), but many cases of IHD result in heart failure [6,7].

Aerobic exercise is a cornerstone of cardiac rehabilitation programs and can improve FC in ischemic cardiac patients [8]. In recent years, there has been some interest in another form of exercise for rehabilitation, namely, eccentric (ECC) exercise [9–15]. Muscle contraction with ECC exercise is defined as the contraction of the muscle while it is elongated. This type of muscle contraction results in greater increases in muscle strength because of the production of greater torque; at the same time, oxygen requirement and cardiovascular stress are reduced as compared with concentric (CON) exercise [16–19]. Thus, ECC exercise seems to be an “economical” type of exercise that has the results of regular exercise (i.e. muscle strengthening) but without causing

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early fatigue and is easily afforded by patients with exercise intolerance. Moreover, ECC exercise is an integral part of daily human activities because it occurs in such activities as walking downhill or descending stairs. In cardiac patients, ECC exercise is not performed solely for a certain muscle but is a general low-intensity exercise for lower limbs.

A randomized clinical trial (RCT) revealed that this type of exercise in coronary patients could significantly improve maximum oxygen uptake (VO_{2peak}) as well as other parameters as compared with typical CON exercise [9]. However, the effectiveness of ECC exercise for FC remains debatable because in another study of ischemic cardiac patients, VO_{2peak} did not show any significant improvement with ECC exercise [15].

To our knowledge, no other study has systematically examined the effect of ECC exercise on FC. This review aimed to explore its efficacy for FC as compared with the standard form of aerobic exercise (CON) in ischemic cardiac patients.

2. Methods

PRISMA guidelines were used for this systematic review [20,21]. We searched for articles published in English from inception to July 2016 in the electronic databases PubMed and all EBSCO Host databases (including Academic Search, CINAHL, Health Source, SportDiscus) with keywords related to both IHD (CAD, heart failure, coronary patients, cardiovascular disease, ischemic heart disease, cardiorespiratory disease, cardiorespiratory patients, myocardial infarction) and ECC exercise (eccentric exercise, eccentric training, eccentric endurance, downhill walking, downhill running, stair descending, negative work) (Appendix 1). Articles retrieved were perused for other relevant references.

The search yield was initially screened by 2 assessors (CS, ME) to remove duplicates and to independently assess titles and abstracts of potentially relevant articles, then the full-text article was retrieved. Disagreements were discussed to reach consensus, and if necessary, with a third reviewer (IM).

2.1. Inclusion criteria

We included articles following the PICOS model:

- men and women over 18 years old, with a diagnosis of IHD (e.g. CAD, heart failure, myocardial infarction) (patients who had undergone heart surgery such as coronary artery bypass grafting or percutaneous coronary intervention could also be included);
- any form of ECC exercise training program;
- comparing no exercise or other forms of exercise programs (e.g. traditional aerobic exercise);
- FC assessed by maximal or submaximal tests;
- and a RCT.

2.1.1. Quality evaluation of studies

The quality of the studies was assessed by methodological and statistical criteria (e.g. randomization, blinding, data comparison before and after the intervention and between groups). The quality of each study was assessed independently by 2 investigators (CK, IM) who used the PEDro scale, which is based on the Delphi List criteria [22] and is considered valid and reliable [23,24]. High quality was considered a score $\geq 7/10$; intermediate quality, a score 4 to 6; and poor quality, a score ≤ 3 .

2.1.2. Statistical analysis

A meta-analysis was performed if sufficient homogeneity existed between at least 2 studies in the pre-defined comparisons.

For articles that did not contain numerical data, the authors were contacted for the data. Meta-analyses of the results are presented as pooled mean differences for continuous data, comparing treatment and control groups with a random-effects model. The existence of statistical heterogeneity between the included studies was assessed by the Chi^2 test and I^2 . Two-sided $P < 0.05$ was considered statistically significant. Analysis involved use of RevMan 5.0 [25].

3. Results

During the initial research, 173 articles were found. After removing duplicates and non-relevant articles, 8 articles remained. Only 4 studies met all inclusion criteria and comprised the necessary data to investigate the effectiveness of eccentric exercise for FC of ischemic cardiac patients (Fig. 1) (Appendix 2).

3.1. Methodological quality of studies

The quality of the studies was moderate: scores ranged from 5 to 7/10 on the PEDro scale (Table 1). All studies were referred for evaluation of the outcome measures before and after the intervention and also between the 2 evaluation groups. Two of these trials involved no form of blindness (by participants, researchers or examiners) [9,12], whereas in the other trials, only assessors were blinded [13,15].

3.2. Characteristics of participants, disease, surgery, and medications

The studies included 13 to 42 patients for a total of 99 patients. Most patients were males ($n = 85$). The mean age was 57 ± 8 years old. Participant characteristics are in Table 2.

In 2 of the studies, the participating patients had CAD [9,13], whereas in the other 2 studies, patients had chronic heart failure [12,15]. In all studies, an inclusion criterion was that the patients with cardiac disease were in stable status, and the patients with CAD should have $> 45\%$ ejection fraction. In studies including CAD patients, 89% of patients (24/27) had previously had acute coronary syndrome; 21 had undergone percutaneous coronary intervention and 3 coronary artery bypass graft.

The main medication for patients was beta-blockers (95%), antiplatelet agents (87%), statins (82%), angiotensin-converting enzyme inhibitors (81%) and diuretics (40%). Receipt of diuretics was more frequent for patients with chronic heart failure than CAD.

3.3. Characteristics of exercise programs

In all studies, the sample was divided into 2 groups, one group following an ECC exercise training program and the other a typical CON aerobic exercise program. None of the studies had a no-exercise group. In all trials, a cycle ergometer was used for the exercises.

Studies differed regarding the parameters of the exercise programs. The total duration of the programs ranged from 5 to 8 weeks. In all studies, the protocol was 3 exercise sessions per week. The total length of each session of the actual duration of an eccentric or a concentric exercise (except for warm-up, rest and recovery time) ranged from 25 to 30 min.

Various factors were used to determine exercise intensity. In some studies, metabolic rate (%) of VO_{2peak} [9], ventilation threshold (VT) [12,13,15] or maximum heart rate (HR) were used [9,12]. In some other studies, subjective symptoms considered were rate of perceived exertion (RPE), used to determine the intensity [12,15]. In 3 studies, the intensity was determined by number of revolutions per minute combined with an adjusted

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