International Journal of Cardiology 166 (2013) 352–358

Contents lists available at SciVerse ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Intermittent versus continuous exercise training in chronic heart failure: A meta-analysis

Neil A. Smart [a,*], Gudrun Dieberg [a], Francesco Giallauria [b]

[a] School of Science and Technology, University of New England, Armidale, NSW 2351, Australia
[b] Department of Clinical Medicine, Cardiovascular and Immunological Sciences, Cardiac Rehabilitation Unit, University of Naples "Federico II", Naples, Italy

ARTICLE INFO

Article history:
Received 15 September 2011
Accepted 18 October 2011
Available online 17 November 2011

Keywords:
Exercise training
Heart failure
Intermittent exercise

ABSTRACT

Introduction: We conducted a meta-analysis of randomized, controlled trials of combined strength and intermittent aerobic training, intermittent aerobic training only and continuous exercise training in heart failure patients.

Methods: A systematic search was conducted of Medline (Ovid) (1950–September 2011), Embase.com (1974–September 2011), Cochrane Central Register of Controlled Trials and CINAHL (1981–September 19 2011). The search strategy included a mix of MeSH and free text terms for the key concepts heart failure, exercise training, interval training and intermittent exercise training.

Results: The included studies contained an aggregate of 446 patients, 212 completed intermittent exercise training, 66 only continuous exercise training, 59 completed combined intermittent and strength training and 109 sedentary controls. Weighted mean difference (MD) in Peak VO_2 was 1.04 ml kg^{-1} min^{-1} and (95% C.I.) was 0.42-1.66 ($p = 0.0009$) in intermittent versus continuous exercise training respectively. Weighted mean difference in Peak VO_2 was −1.10 ml kg^{-1} min^{-1} (95% C.I.) was −1.83–0.37 $p = 0.003$ for intermittent only versus intermittent and strength (combined) training respectively. In studies reporting V_E/VCO_2 for intermittent versus control groups, MD was −1.50 [(95% C.I. −2.64, −0.37), $p = 0.01$] and for intermittent versus continuous exercise training MD was −1.35 [(95% C.I. −2.15, −0.55), $p = 0.001$]. Change in peak VO_2 was positively correlated with weekly exercise energy expenditure for intermittent exercise groups ($r = 0.48$, $p = 0.05$).

Conclusions: Combined strength and intermittent exercise appears superior for peak VO_2 changes when compared to intermittent exercise of similar exercise energy expenditure.

1. Introduction

In patients with stable heart failure on optimal cardiac medication, exercise training (ExT) is usually recommended 3 to 5 days per week for 20 to 60 min[1]. Aside from the nature of the training activity, the effects of training may vary with different dose parameters, specifically program length, session duration and frequency and workload or intensity [2]. In the most severely impaired patients, with initial exercise intolerance, sessions may initially be limited to 3–5 min duration with 3 or 4 sessions completed during the course of the day [3]; however, recent work has suggested that if total exercise energy expenditure is standardized then intermittent exercise training programs may elicit superior benefits to heart failure patients compared to continuous exercise training sessions [4].

High intensity, repeated intermittent work periods separated by recovery periods have been shown to be efficacious in heart failure patients [5], and interval stress has been shown to be as effective as continuous workloads in older, healthy and post coronary artery bypass surgery populations [6]. In a systematic review of 81 heart failure ExT studies only two of these reported peak VO_2 changes of 10% [7] and 20% [5] respectively compared with 16.5% overall change in continuous exercise training and similar improvements with strength training [2]. The underlying theory is that higher intensity, intermittent stress is more likely to promote peripheral adaptations and produce concurrent improvements in functional capacity. Recent work has shown that reductions of brain natriuretic peptide, a marker of myocardial stretch, may be greater in high intensity (90% peak VO_2), rather than moderate intensity (70% peak VO_2) exercise training in patients with severe left ventricular dysfunction [4].

The aim of this work was to conduct a systematic review and meta-analysis of randomized, controlled trials of intermittent exercise training, to examine the magnitude of change in peak VO_2 and V_E/VCO_2 slope in heart failure patients, compared to three

* Corresponding author. Tel.: +61 2 6773 4076; fax: +61 2 6773 5011.
E-mail address: Nsmart2@une.edu.au (N.A. Smart).

0167-5273/$ – see front matter
doi:10.1016/j.ijcard.2011.10.075

Table 1
MEDLINE search strategy.

#1 (intermittent exercise training*):ti,ab,kw
#2 MeSH descriptor chronic heart failure, this term only
#3 MeSH descriptor interval training, explode all trees
#4 MeSH descriptor cardiomyopathy, this term only
#5 "left ventricular dysfunction":ti,ab,kw
#6 "maximal oxygen consumption":ti,ab,kw
#7 (VO_2 peak):ti,ab,kw
#8 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8)

comparator groups; combined strength and intermittent aerobic training, continuous exercise training and sedentary controls. A secondary aim was to examine whether magnitude of change in peak VO_2 was related to exercise energy expenditure.

2. Methods

For the purpose of this study intermittent exercise was defined as at least three bouts of exercise, of 5 min duration or less, interspersed with a standard rest period of 5 min duration or less. The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology.

2.1. Search strategy

Potential studies were identified by a systematic review librarian. A systematic search was conducted of Medline (Ovid) (1950–September 2011), Embase.com (1974–September 2011), Cochrane Central Register of Controlled Trials and CINAHL (1981–September 2011). The search strategy included a mix of MeSH and free text terms for the key concepts heart failure, exercise training, interval training and intermittent exercise training and these were combined with a sensitive search strategy to identify randomized controlled trials. Reference lists of papers found were scrutinized for new references. All identified papers were assessed independently by two reviewers (NS and GD) and a consensus reached by consulting a third reviewer (FG) if required. Searches of published papers were conducted up until September 2011. A summary of the search strategy can be seen in Table 1.

2.1.1. Inclusions

Randomized, controlled trials of exercise training in heart failure patients, for a minimum of 2 weeks, that compared intermittent exercise training with either continuous exercise training or a sedentary control group. There were no language restrictions.

2.1.2. Exclusions

Animal studies, review papers and non-randomized controlled trials were excluded. Studies that included participants who were non-heart failure or healthy in either treatment or control groups were also excluded. Authors were contacted to provide missing data or to clarify if data was duplicated in multiple publications by the same author or research group, incomplete data or data from an already included study resulted in exclusion. Studies of physical therapy other than aerobic or strength exercise (e.g. electrical stimulation or tai chi) and acute exercise rather than training response studies were also excluded.

2.1.3. Studies included in the review

We examined conference proceedings and the latest editions of relevant journals not yet available on electronic databases. Fig. 1 shows the PRISMA flow diagram, initial screening identified 110 potential reports, 96 studies were excluded, 76 for inappropriate study design, 8 for inappropriate outcome data, 6 were animal studies, 4 because they were review articles and two were duplicate studies, leaving fourteen eligible trials [4,7–19], however one study did not have relevant outcome measures and was used for descriptive data only [14].

2.2. Data synthesis

Data relating to peak VO_2, V_E/VCO_2 slope, heart failure patient characteristics and exercise training protocols were reviewed. Information was archived in a database. The primary outcome measure following exercise training was post exercise change in peak VO_2, in ml kg^{-1} min^{-1}. Secondary outcomes were change in V_E/VCO_2 slope with training, and exercise program energy expenditure in kcal $week^{-1}$. Measures of study quality were also recorded and also inter-group variation with respect to baseline age, gender, left ventricular ejection fraction (LVEF %).

2.2.1. Exercise program parameters

Where possible we also calculated, using established methods [20], total work completed during the cycle ergometry portions of the exercise training programs (Kcal) and mean weekly calorie expenditure. These calculations were conducted in order to determine a dose–response relationship with change in peak VO_2.

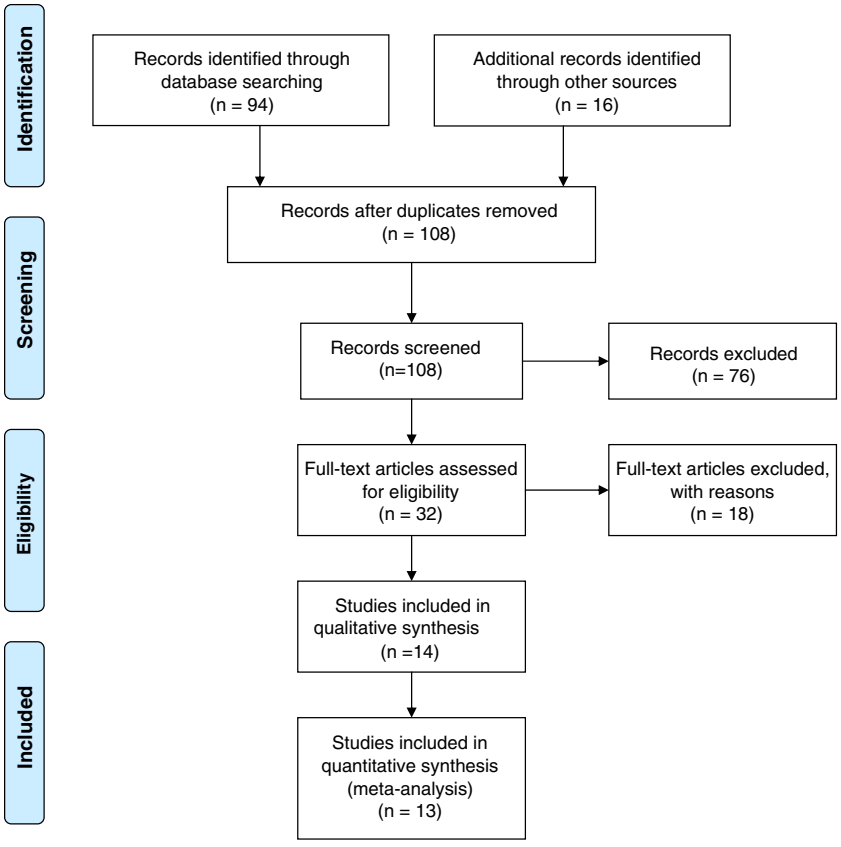

Fig. 1. PRISMA 2009 flow diagram.