Heart, Lung and Circulation (2015) **24,** 149–157
1443-9506/04/$36.00
http://dx.doi.org/10.1016/j.hlc.2014.09.001

ORIGINAL ARTICLE

Interval Training Versus Continuous Exercise in Patients with Coronary Artery Disease: A Meta-Analysis

Adrian D. Elliott, Ph.D [a,b*], Kanchani Rajopadhyaya, Ph.D [c], David J. Bentley, Ph.D [a], John F. Beltrame, MBBS, Ph.D [c], Edoardo C. Aromataris, Ph.D [b]

[a]School of Medical Sciences, University of Adelaide, Australia
[b]School of Translational Health Science, University of Adelaide, Australia
[c]The Queen Elizabeth Hospital and Discipline of Medicine, University of Adelaide, Australia

Received 30 June 2014; received in revised form 29 August 2014; accepted 2 September 2014; online published-ahead-of-print 16 September 2014

Background High aerobic capacity is inversely related to cardiovascular disease morbidity and mortality. Recent studies suggest greater improvements in aerobic capacity with high-intensity interval training (interval) compared to moderate-intensity continuous aerobic exercise (continuous). Therefore we perform a meta-analysis of randomised controlled trials comparing the effectiveness of INTERVAL versus CONTINUOUS in aerobic capacity, amongst patients with stable coronary artery disease (CAD) and preserved ejection fraction

Methods We searched PubMed, EMBASE, CINAHL, the Australia and New Zealand Clinical Trials Register, clinicaltrials.gov and TROVE for randomised controlled trials comparing INTERVAL with CONTINUOUS in patients with CAD. Studies published in the English language up to December 2013 were eligible for inclusion. Aerobic capacity, quantified by peak oxygen consumption (VO_{2peak}) post exercise training was extracted and compared post-intervention between INTERVAL and CONTINUOUS by way of a fixed model meta-analysis. Secondary outcomes including anaerobic threshold, blood pressure and high-density lipoproteins (HDL) were also analysed.

Results Six independent studies with 229 patients ($n = 99$ randomised to INTERVAL) were included in the meta-analysis. There was a significantly higher increase in VO_{2peak} following INTERVAL compared to CONTINUOUS (Weighted Mean Difference = 1.53 ml•kg^{-1}min^{-1}, 95% CI 0.84 to 2.23) with homogeneity displayed between studies (Chi Squared = 2.69; $P = 0.7$). Significant effects of INTERVAL compared to CONTINUOUS were also found for anaerobic threshold but not systolic blood pressure.

Conclusion In patients with CAD, INTERVAL appears more effective than CONTINUOUS for the improvement of aerobic capacity in patients with CAD. However, long-term studies assessing morbidity and mortality following INTERVAL are required before this approach can be more widely adopted.

Keywords Rehabilitation • Myocardial infarction • Coronary artery bypass graft • Risk factors • Oxygen uptake

*Corresponding author at: School of Medical Sciences, University of Adelaide. Tel.: +(0061) 8 8313 3194.,
Email: adrian.elliott@adelaide.edu.au

Introduction

Exercise-based cardiac rehabilitation is an effective strategy for reducing total and cardiovascular mortality in patients with coronary artery disease (CAD) [1]. Furthermore, aerobic fitness has been established as a strong predictor of cardiovascular [2,3] and all-cause mortality [4]. Defining aerobic fitness by way of cardiopulmonary exercise testing has become increasingly available in many rehabilitation settings, where peak oxygen consumption (VO_{2peak}) can be directly measured as the gold standard for aerobic capacity. Increases in VO_{2peak} have been shown to relate to improvements in mortality risk [5], where every 1-metabolic equivalent (1-MET = 3.5 $ml \bullet kg^{-1}min^{-1}$ VO_2) increase yields a 13% improvement in survival. Exercise training-induced increases in aerobic capacity are therefore highly desirable for the improvement of patient outcomes.

Optimising exercise rehabilitation to maximise the potential increase in aerobic capacity is an important factor in the prescription of exercise. In patients with CAD, traditional exercise prescription has included continuous aerobic exercise, such as walking or cycling, at a moderate intensity (40-80% VO_{2peak}) for 30-60 minutes [6]. However, recent evidence in healthy participants [7,8], heart failure patients [9,10] and patients with cardiometabolic disease [11] suggests that high-intensity interval training (INTERVAL) may be a more effective strategy for the improvement of aerobic capacity than continuous, moderate intensity exercise training (CONTINUOUS).

High-intensity interval training is characterised by brief intermittent bursts of exercise interspersed by active recovery periods, and has shown a number of benefits in patients with CAD, including improvements in aerobic capacity, anaerobic threshold, endothelial function and cardiac function [9,12].

Studies comparing INTERVAL with CONTINUOUS training in patients with heart disease typically prescribe intervals of up to four minutes duration at an intensity of approximately 85-95% peak heart rate (HR_{peak}) [9,13,14]. Alternatively, shorter durations of one to two minutes have also been applied with a 1:1 work:rest ratio [15,16]. Likewise, both shorter [7] and longer intervals [8] have been shown to increase aerobic capacity compared to CONTINUOUS in healthy participants.

In many instances, the benefits on aerobic capacity of INTERVAL appear to exceed the improvements seen with CONTINUOUS training. Previous meta-analyses of studies recruiting heart failure [10] and cardiometabolic disease patients [11] indicate that INTERVAL results in increases of approximately 2-3 ml/kg/min VO_{2peak} greater than that observed with CONTINUOUS training.

Previous systematic reviews have included studies comparing INTERVAL with no exercise [17] or patients with metabolic and/or other lifestyle diseases in addition to those with CAD [11]. More recently, a meta-analysis revealed greater improvements in aerobic capacity with INTERVAL compared with CONTINUOUS in patients with CAD [18]. However, since publication of this meta-analysis, a further study has been published comparing the two approaches. Importantly, the meta-analysis by Pattyn et al, included studies in which patients had ischaemic heart failure and ejection fractions <40% [9]. Additionally, in some studies analysed, there were no differences in the actual exercise intensity between the two training methods. The aim of the present study was to perform a meta-analysis of all randomised controlled trials studies comparing the effectiveness of INTERVAL with CONTINUOUS on aerobic capacity, defined using VO_{2peak}, amongst patients diagnosed with stable CAD in the absence of disclosed heart failure.

Methods

Study Selection

The search aimed to find both published and unpublished studies. The search was restricted to studies published in the English language prior to December 2013. A three-step search strategy was employed; an initial limited search of PubMed and CINAHL was undertaken followed by analysis of text words contained in the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms was then undertaken across PubMed, EMBASE, CINAHL, the Australia and New Zealand Clinical Trials Register, clinicaltrials.gov and TROVE (Fig. 1). Thirdly, the reference lists of all identified reports and articles were searched for additional studies. At this time, one further study came to the attention of the authors.

Keywords used in the search included those relating to the exercise intervention (e.g. exercise rehabilitation, interval exercise, high-intensity exercise) combined with those specific to the population (e.g. coronary artery disease, ischemic heart disease, myocardial infarction). Full-text articles were retrieved after review of the title and abstract. Criteria for inclusion were all of the following; i) randomised controlled trials comparing INTERVAL with CONTINUOUS in patients with stable CAD in the absence of heart failure, ii) studies prescribing an exercise program for at least four weeks, and iii) studies including aerobic capacity as a reported outcome. Secondary outcomes for this study included the cardiovascular risk factor profile including resting systolic blood pressure, low-density lipoprotein (LDL) and high-density lipoprotein (HDL). To be eligible for inclusion, INTERVAL was defined as brief (1-4 mins), intermittent bouts of high-intensity (>85% HR_{peak} or equivalent) rhythmic exercise such as cycling, jogging, or walking, interspersed by periods of active recovery. Both supervised and home-supervised exercise was considered for inclusion. Continuous, moderate-intensity exercise was defined as at least 30 minutes of rhythmic aerobic exercise, such as cycling, walking, running or swimming, performed at a moderate-intensity (<80% HR_{peak} or equivalent) that is sustainable for the duration of the session.

Assessment of Methodological Quality

Studies selected for inclusion were assessed for methodological validity by two independent reviewers (A.D.E and D.J.B)