International Journal of Cardiology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Cardiology

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

Review

# Implementing resistance training in the rehabilitation of coronary heart disease: A systematic review and meta-analysis

Paul D. Xanthos [1,2], Brett A. Gordon [1,2], Michael I.C. Kingsley [*,1,2]

*Discipline of Exercise Physiology, La Trobe Rural Health School, La Trobe University, Bendigo, Victoria, Australia*

ARTICLE INFO

*Article history:*
Received 13 July 2016
Received in revised form 5 December 2016
Accepted 16 December 2016
Available online xxxx

*Keywords:*
Resistance training
Heart disease
Physical function
Cardiac rehabilitation
Intensity
Duration

ABSTRACT

*Background:* Resistance training has demonstrated efficacy in cardiac rehabilitation programs, but the optimal prescription of resistance training is unknown. This systematic review with meta-analysis compared the effectiveness of cardiac rehabilitation consisting of resistance training either alone (RT) or in combination with aerobic training (CT) with aerobic training only (AT) on outcomes of physical function. Further, resistance training intensity and intervention duration were examined to identify if these factors moderate efficacy.

*Methods:* Six electronic databases were searched to identify studies investigating RT, coronary heart disease and physical function. The overall quality of evidence was assessed using the GRADE approach. Meta-analyses were performed when possible and qualitative analysis was performed for the remaining data.

*Results:* Improvements in peak oxygen uptake (WMD: 0.61, 95% CI: 0.20–1.10), peak work capacity (SMD: 0.38, 95% CI: 0.11–0.64) and muscular strength (SMD: 0.65, 95% CI: 0.43–0.87) significantly favoured CT over AT with moderate quality evidence. There was no evidence of a difference in effect when comparing RT and AT. Shorter duration CT was superior to shorter duration AT for improving peak oxygen uptake and muscular strength (low quality evidence) while longer duration CT was only superior to longer duration AT in improving muscular strength (moderate quality evidence).

*Conclusions:* CT is more beneficial than AT alone for improving physical function. Although preliminary findings are promising, more high-quality evidence is required to determine the efficacy of high intensity resistance training. Shorter duration interventions that include resistance training might allow patients to return to their normal activities of daily living earlier.



## 1. Introduction

Coronary heart disease (CHD) is a major cause of death and disability. In 2012, CHD was responsible for approximately 7.4 million deaths worldwide [1]. Cardiac rehabilitation is accepted as an essential component in the management of individuals with CHD and attending cardiac rehabilitation reduces the risk of all-cause mortality, cardiac mortality and re-infarction [2]. In addition, enhancing an individual's ability to return to activities of daily living (ADL), including domestic, occupational and recreational activities, has been identified as an important goal of cardiac rehabilitation to allow successful integration back into society [3–5]. Enhanced physical function in CHD patients, via increases in cardiorespiratory fitness and muscular strength, is required to improve the performance of ADL [6–8]. Consequently, it is important that cardiac rehabilitation programs foster improvements in both cardiorespiratory fitness and muscular strength. Furthermore, diminished levels of cardiorespiratory fitness and muscular strength have been associated with an increased risk of mortality [9,10].

Cardiac rehabilitation programs have traditionally been based on aerobic exercises, with resistance exercises only playing a subsidiary role [11]. While purposeful resistance exercises were originally assumed to be dangerous due to rapid increases in heart rate (HR) and arterial blood pressure [12], it has since been shown that resistance exercises can be safely performed in cardiac rehabilitation up to 90% of 1 repetition maximum (1RM) [13–15]. A previous meta-analysis reported that combining resistance and aerobic training significantly enhanced peak work capacity and muscular strength when compared to aerobic training [16]. Another meta-analysis by Yamamoto et al. [17] compared resistance training interventions (either alone or combination with aerobic training) to usual care or aerobic training alone in patients with CHD. Although these authors reported that resistance training/combined training enhanced peak oxygen uptake and muscular strength [17], intensity and duration were identified as moderating

*Abbreviations:* 1RM, 1 repetition maximum; 95% CI, 95% confidence interval; ADL, activities of daily living; AT, aerobic training alone; CHD, coronary heart disease; CT, combined training; RT, resistance training alone; SMD, standardised mean difference; WMD, weighted mean difference.

* Corresponding author.
*E-mail addresses:* p.xanthos@latrobe.edu.au (P.D. Xanthos), b.gordon@latrobe.edu.au (B.A. Gordon), m.kingsley@latrobe.edu.au (M.I.C. Kingsley).
[1] Address: La Trobe University, La Trobe Rural Health School, PO Box 199, Bendigo, Victoria, Australia, 3552.
[2] This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

http://dx.doi.org/10.1016/j.ijcard.2016.12.076
0167-5273/

factors that require future research [17]. Therefore, the dose of resistance training in cardiac rehabilitation including intensity and duration of the resistance component has not been systematically investigated and remains unknown.

The continual progression of purposeful resistance training, through alterations in frequency, time and intensity, can induce substantial improvements in muscular strength [18], which can lead to improvements in ADL [19] and decreased mortality risk [10]. In cardiac rehabilitation, resistance training has been recommended at a low–moderate intensity with 10 to 15 repetitions per exercise [20]. However, a dose–response relationship exists for resistance training intensity, where gains in muscular strength improve with greater resistance training intensity, even in people aged >65 years [21]. As approximately two-thirds of patients attending cardiac rehabilitation are older than 65 years [22,23], investigation into resistance training intensity during cardiac rehabilitation is warranted. If high intensity resistance training is prescribed in cardiac rehabilitation, greater increases in muscular strength might be elicited compared to resistance training prescribed at low or moderate intensities, with greater functional improvements obtained [19,21] and further reductions of mortality risk [10].

In addition to personal benefits, returning patients to work following a cardiac event is important due to the detrimental effect of lost productivity and wage replacement on a community's economy [24]. The median time taken to return to work after a cardiac event can be as long as 13 weeks [25,26]. As such, strategies that facilitate a speedier return to work for cardiac rehabilitation patients are important and could decrease some of the indirect costs associated with CHD [24]. Poor physical function has been identified as an important factor that delays return to work [27]. However, attendance at cardiac rehabilitation, which can increase physical function [28], is relatively poor, with approximately one third of eligible patients attending cardiac rehabilitation throughout the developed world [29–31]. One reason that is often cited for non-attendance at cardiac rehabilitation is a perceived lack of time [32,33]. Although different models exist for the delivery of cardiac rehabilitation, outpatient cardiac rehabilitation programs are generally 6 to 12 weeks in duration [3,34]. Therefore, shorter duration cardiac rehabilitation programs with the inclusion of resistance training might be warranted if they can reduce the time-burden on patients, leading to increased cardiac rehabilitation attendance.

Given that CHD remains a major burden worldwide [1], optimising the treatment of CHD is of importance. This systematic review with meta-analysis aimed to compare resistance training, prescribed alone (RT) or in combination with aerobic training (CT), to aerobic training alone (AT) on physical capacity. A further aim was to investigate how alterations in resistance training intensity and intervention duration moderated physical capacity outcomes in a CHD population.

## 2. Methods

### 2.1. Search strategy

Six electronic databases (PubMed, Medline, CINAHL, Scopus, Embase and Cochrane) were searched from the earliest available date to November 2016. Search terms were grouped into three constructs: 'cardiac disease', 'resistance training' and 'functional capacity'. These constructs were searched individually and in combination using the 'AND' operation. Search terms for 'cardiac disease' were: heart disease(s), cardiac disease(s), coronary heart disease(s), coronary artery disease(s), angina, myocardial infarction, ischemic heart disease(s), cardiac revascularisation, cardiac revascularisation, myocardial ischemia, coronary artery bypass (surgery), ischemic artery disease(s), coronary infarction and coronary disease(s). Search terms for 'resistance training' were: resistance training, weight training, strength training, weight lifting, muscle strengthening, progressive resistance training, circuit training, exercise training, muscle contraction(s) and exercise therapy. Search terms for 'functional capacity' were: functional capacity, physical function, aerobic capacity, muscle strength, power, muscle power, muscle torque, $\dot{V}O_{2max}$, $\dot{V}O_{2peak}$, oxygen uptake, exercise capacity and exercise tolerance. One investigator (PX) reviewed studies by title and excluded inappropriate studies by the following exclusion criteria: 1) non-human participants or study not written in English; 2) not an original investigation; 3) not an adult population; 4) population had not experienced angina, myocardial infarction or acute coronary heart disease; 5) no prescribed exercise training; 6) insufficient RT prescription (i.e. RT not completed at least twice a week, number and/or names/descriptions of RT exercises not reported, intensity of RT exercises not reported, number of sets of RT exercises not reported, number of repetitions per set of RT exercises not reported); and 7) no functional outcome measures of cardiorespiratory fitness, muscular strength or muscular power. One investigator (PX) reviewed all studies by abstract while two investigators (BG and MK) reviewed half of the abstracts each. A unanimous decision was required between PX and BG/MK to exclude a study by abstract. Split decisions resulted in that study being reviewed by the final investigator (either BG or MK), whereby the majority decision resulted in that study being excluded or included. Full-text review was undertaken in the same manner as abstract review.

### 2.2. Data extraction

Data describing population characteristics, intervention duration and exercise prescription, control duration and exercise prescription, follow-up times and outcomes were extracted from included studies. Descriptive statistics from individual studies relating to change in: 1) cardiorespiratory fitness, as measured by $\dot{V}O_{2peak}$, exercise time or power output, and 2) muscular strength, as measured by 1RM or as peak isokinetic torque, were entered directly into Review Manager (RevMan, Version 5.3; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark) for analysis. Required data were not able to be extracted from 3 studies. Where the required data were not published and authors were unable to be contacted, the means, standard deviations and participant numbers were obtained from a previously published meta-analysis [16] for inclusion in this meta-analysis.

### 2.3. Assessment of study quality

Assessment of study and outcome quality for each meta-analysis was completed according to the GRADE approach for systematic reviews [35]. Quality of evidence was assessed on a four-point scale including 'high', 'moderate', 'low' and 'very low' [35]. Quality of evidence for meta-analyses began at the high level and was downgraded to lower levels of evidence when risk of bias, inconsistency, indirectness, imprecision or publication bias were present.

### 2.4. Data analysis

This systematic review with meta-analyses aimed to assess the effectiveness of resistance training in individuals with CHD compared to aerobic training (AT). Studies including resistance training as an intervention were grouped into: 1) interventions that included resistance training in combination with aerobic training (CT); or 2) resistance training alone (RT). Both CT and RT alone were compared to AT alone for change in cardiorespiratory fitness ($\dot{V}O_{2peak}$ and peak work capacity) and change in muscular strength. In studies with more than one appropriate intervention group, the sample sizes, means and standard deviations were condensed into a single sample size, mean and standard deviation according to Higgins and Deeks [36]. To assess the influence of resistance training intensity on change in cardiorespiratory fitness and muscular strength, CT studies were stratified into high (≥70% 1RM or <12 repetitions per set) and low–moderate intensities (<70% 1RM or ≥12 repetitions per set) according to a previously published systematic review with meta-analysis [37]. Combined training studies were stratified into shorter duration (<12 weeks) and longer duration (≥12 weeks)

Please cite this article as: P.D. Xanthos, et al., Implementing resistance training in the rehabilitation of coronary heart disease: A systematic review and meta-analysis, Int J Cardiol (2016), http://dx.doi.org/10.1016/j.ijcard.2016.12.076