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Original article

Effects of resistance training on muscle strength, exercise capacity, and mobility in middle-aged and elderly patients with coronary artery disease: A meta-analysis

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ABSTRACT

Background: Resistance training (RT) is a core component of cardiac rehabilitation. We investigated the effects of RT on exercise capacity, muscle strength, and mobility in middle-aged and elderly patients with coronary artery disease (CAD).
Methods: We searched for randomized controlled trials of RT versus usual care, or combined RT and aerobic training (AT) versus AT alone, and identified 440 trials in total from inception to January 2014. Participants who had myocardial infarction, coronary revascularization, angina pectoris or CAD were included in the analysis. Those who had heart failure, heart transplants with either cardiac resynchronization therapy or implantable defibrillators were excluded.
Results: Twenty-two trials totaling 1095 participants were analyzed. We performed random-effects meta-analysis. In middle-aged participants, RT increased lower extremity muscle strength [standardized mean difference (SMD): 0.65, 95% confidence interval (CI): 0.35 to 0.95], upper extremity muscle strength (SMD: 0.73, 95% CI: 0.48 to 0.99) and peak oxygen consumption (VO_2) [weight mean difference (WMD): 0.92 mL/kg/min, 95% CI: 0.12 to 1.72], but did not improve mobility compared with the control. In elderly participants, RT increased lower extremity muscle strength (SMD: 0.63, 95% CI: 0.05 to 1.21), upper extremity muscle strength (SMD: 1.18, 95% CI: 0.56 to 1.80), and peak VO_2 (WMD: 0.70 mL/kg/min, 95% CI: 0.03 to 1.37), and improved mobility (SMD: 0.61, 95% CI: 0.21 to 1.01) compared with the control.
Conclusions: Resistance training could increase exercise capacity and muscle strength in middle-aged and elderly patients, and mobility in elderly patients, with CAD.

Introduction

Cardiac rehabilitation is a comprehensive intervention composed of exercise, risk factor education, behavior change, psychological support, and various approaches that address common risk factors of coronary artery disease (CAD) [1]. In particular, exercise therapy is recognized as an integral component of cardiac rehabilitation [1]. The American Heart Association (AHA) guideline [1] recommends aerobic training (AT) and resistance training (RT) as the core elements of exercise-based cardiac rehabilitation. A Cochrane meta-analysis found that combined AT and RT was associated with a 28% reduction in mortality and a 31% reduction in hospital readmission for CAD patients [2]. However, the AHA guideline highlights that benefits of an RT-only regimen remain unclear because few meta-analyses have been conducted on the benefits of RT-only rehabilitation in CAD patients [1]. As reduced cardiac output and tissue hypoxia in CAD induce expression of myostatin [3] and inflammatory cytokines [4], leading to the progressive decline of skeletal muscle mass [4], RT is more likely to be an effective intervention for CAD patients with poor skeletal muscles compared with AT.

Several meta-analyses have highlighted the benefits of RT among community-dwelling people. RT has been shown to

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increase exercise capacity and mobility [5], to reduce mortality [5], and to improve serum lipids (e.g. high-density lipoprotein levels) [6]. In particular, RT is more effective in elderly people compared with middle-aged people because skeletal muscle strength in elderly people is much poorer [7]. The number of elderly patients with CAD has increased by approximately 60% in the past few decades, and has contributed to an increase in elderly people with CAD participating in cardiac rehabilitation [8]. Several studies have demonstrated that loss of skeletal muscle strength and muscle mass with advancing age, also known as sarcopenia of aging, is a highly prevalent condition among elderly people [9]. Sarcopenia is thought to be caused by decreased motor units, growth hormones, insulin-like growth factors, and impaired mitochondrial function [10]. For these reasons, it is necessary to divide patients into the age groups of middle-aged and elderly in order to verify the effect of RT on specific older age groups.

The purpose of this study was to clarify the effects of RT on exercise capacity, skeletal muscle strength, and mobility in middle-aged and elderly patients with CAD.

Methods

Search methods for identification of studies

This meta-analysis was carried out according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Statement [11]. Searches of studies from inception to January 2014 were conducted using the following electronic databases: Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL, and OvidSP. The search strategy was developed with an information specialist, appropriately modified for each database and included a combination of free text words (tw), words in titles/abstracts (tiab), and medical subject headings (mesh), such as ‘‘myocardial infarction’’, ‘‘myocard (ischamia or ischemia)’’, ‘‘coronary artery bypass’’, ‘‘angina’’, ‘‘coronary (disease, bypass, thrombo or angioplast)’’, ‘‘resistance (training, exercise or program)’’, ‘‘weight (bearing, lifting, training, exercise or program)’’, ‘‘isokinetic (training, exercise or program)’’, ‘‘isometric (training, exercise or program)’’ and ‘‘randomized controlled trial’’. Searches were limited to reviewed research involving human participants. Different terms and variations in the spellings of terms used in other countries were included in the search strategy in order to ensure that the search captured all possibly relevant studies on the topic. No language restrictions were applied.

Inclusion and exclusion criteria

Identified studies were randomized controlled trials (RCTs) of RT versus usual care, or combined RT and AT vs AT alone. Resistance training was defined as muscular fitness using free weights, machines with stacked weights or pneumatic resistance, and rubber bands. In this meta-analysis, male and female participants of any age from hospital and community settings who had a history of the following conditions or procedures were included: myocardial infarction (MI), or coronary revascularization (coronary artery bypass grafting, percutaneous transluminal coronary angioplasty, or coronary artery stent), angina pectoris or CAD defined by angiography. Excluded from the analysis were participants who had heart failure, heart transplants with either cardiac resynchronization therapy or implantable defibrillators.

Study selection

Two investigators (SY and KH) independently screened the titles and abstracts of all studies and included the full test according to the described search strategy and criteria, and resolved any disagreements through discussion.

Assessment of risk of bias in included studies

SY and KH independently assessed risk of bias for each study using the risk of bias tool in the Cochrane Handbook for Systematic Reviews of Interventions [12]. Any disagreements were resolved by discussion. Due to a change in methods, SY and EO independently reassessed risk of bias using the updated format of the tool, which is required for all studies already included in the previous version of the tool.

Data synthesis and analysis

The ages of participants from the included studies were confirmed and participants were divided into two groups: middle-aged (<65 years) and elderly (≥65 years). In this analysis, the control group includes participants with either usual care or AT alone. Data synthesis and analyses were performed using Review Manager (RevMan) version 5.3. Continuous outcome measures were expressed as a change in mean ± standard deviation (SD) from baseline to follow-up and were pooled as the weight mean difference (WMD) or standardized mean difference (SMD). When changes in SD for each group were not available, they were reconstructed from the *p*-value for difference in means between groups using the RevMan calculator. When there were 10 or more studies in a meta-analysis, we created and examined funnel plot asymmetry visually to explore publication bias. Heterogeneity was assessed among included studies both qualitatively (by comparing the characteristics of included studies) and quantitatively (using the chi-squared test of heterogeneity and I^2 statistic). Data from each study were pooled using random-effects modeling where appropriate. To examine the robustness of results, we performed meta-analyses using fixed effects models after attributing less weight to small trials. We used these meta-analyses only if their results differed from those of the random-effects models. When an I^2 score of >75% was obtained, heterogeneity was considered to be substantial and subgroup analysis was performed.

Results

Study selection

A total of 440 studies were identified after screening titles and abstracts (Fig. 1), and 406 were excluded. Of the remaining 34 trials, a further 12 studies were excluded for the following reasons: being review papers ($n = 2$), lack of randomization ($n = 4$), lack of outcome measurements ($n = 2$), inappropriate interventions ($n = 3$), and featuring patients with heart failure ($n = 1$). A total of 22 studies [13–34] were included in the analysis.

Study characteristics

Characteristics of the included studies, including participant information, are presented in Table 1. Six studies included only post-MI patients and three studies included only patients undergoing cardiac surgery. The total number of participants from the 22 studies was 1095. Of these studies, 17 included middle-aged participants ($n = 804$) and 5 included elderly participants ($n = 291$).

Risk of bias in included studies

Risk of bias is summarized in Table 2. This is due to a lack of blinding of participants and personnel, which was made difficult because personnel taught and supervised participants during RT.