

Review Article

Exercise-Based Cardiac Rehabilitation for Elderly Patients with Coronary Artery Disease

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Abstract

The exercise-based cardiac rehabilitation (CR) composed of aerobic and resistance training has been established as a fundamental intervention to decrease mortality and cardiovascular events of patients with coronary artery disease (CAD) since 1970-1980 years. However, the prescription of traditional training is recently difficult for CAD patients because the number of elderly patients with low mobility has increased. In particular, mobility of CAD patients decreases to about 70% relative to that of healthy people. Reduced mobility has a direct effect on cardiovascular events and mortality. Therefore, the main goals of elderly patients with CAD are to maintain or improve mobility, in addition to secondary prevention and decreasing mortality ratios. Other methods, i.e. interval training, training using neuromuscular electrical stimulation or balance training, have been proposed in addition to traditional training program (aerobic and resistance training) for elderly patients with CAD. Some studies have proved the effectiveness of these training programs. We must prescribe the evidence-based methods for training program on considering elderly patients' clinical characteristics or condition.

ABBREVIATIONS

AHA: American Heart Association; AT: Anaerobic Threshold; CAD: Coronary Artery Disease; CPX: Cardiopulmonary Exercise Testing; CR: Cardiac Rehabilitation; ESC: European Society of Cardiology; ICU: Intensive Care Unit; METs: Metabolic Equivalents; NMES: Neuromuscular Electrical Stimulation

INTRODUCTION

Although coronary artery disease (CAD) is one of the major causes of death according to World Health Statistics 2015, [1] the life expectancy of CAD patients has improved in recent years. Therefore, secondary prevention of re-admission and mortality of these patients is an important outcome for CAD patients after hospital discharge. Drug therapy is the most fundamental intervention as the strategy of secondary prevention. In recent decades, cardiac rehabilitation (CR) is recognized the similar amount of effectiveness intervention as drug therapy [2,3]. Cardiac rehabilitation (CR) is a comprehensive intervention composed of exercise, risk factor education, behavior change, psychological support, and various approaches that address

common risk factors of CAD [2,3]. In particular, American Heart Association (AHA) guideline recommend that exercise-based CR is recognized as an integral component of cardiac rehabilitation [3]. Many studies have shown that an exercise-based CR program consisting of aerobic and resistance training is an effective intervention to restore physical function [4,5] and exercise capacity [6,7], and to reduce difficulty in physical activities of daily living [8,9] in CAD patients. Furthermore, a Cochrane meta-analysis reported that exercise-based CR was associated with a 28% reduction in mortality and a 31% reduction in hospital readmission for CAD patients [10]. These results are of similar amount as beta-blocker or angiotensin-converting enzyme inhibitor. In addition, approximately 25% of CAD patients have mild depressive symptoms or anxiety, which are poor prognostic factors [11-13]. Some randomized control trials reported that exercise-based CR decreased rate of depressive symptoms or anxiety for CAD patients [10]. The safety of exercise-based CR has been verified worldwide. A scientific statement of AHA in 2007 reported that the incidence rates during exercise were 1 event/60,000-80,000 hours [14]. Similarly, multicenter study by the Japanese Circulation Society revealed that the incidence rates

were 1 event/383,096 patient-hours [15]. These results suggest that exercise-based CR is extremely safe.

Recent study shows that the profile of CAD patients entering exercise-based CR has evolved over the past 10 years [16]. The number of elderly patients with CAD has increased by approximately 60% in the past few decades [16]. Although the main goals of middle-aged CAD patients are secondary prevention and decreasing mortality ratios, those of elderly CAD patients are to maintain or increase mobility, which is defined as either the inability to walk without assistance or having a slow walking speed, in addition to secondary prevention [17]. In fact, walking speed decreases progressively with age, and in particular declines very rapidly over the age of 60 years. In a cross-sectional study by our group, walking speed of CAD patients decrease to about 70% relative to that of healthy people [18]. Furthermore, a three-year cohort study demonstrated that elderly CAD patients with a slow walking speed (<90 m/min for men and <81 m/min for women) have a two- to three-fold higher risk of a cardiovascular event compared to those with a fast walking speed [19]. For those reasons, we need to make a training program should be targeted to increase mobility. The aim of this review is to suggest evidence-based methods for training of elderly CAD patients, with the hope that the training program should be individually tailored, after adequate evaluation of baseline patients' physical performance.

AEROBIC TRAINING

Evidence of exercise capacity

Exercise capacity status (peak oxygen uptake [VO_2] or metabolic equivalents [METs]) becomes well-established predictors of cardiovascular events and mortality. These prognostic markers are obtained by the cardiopulmonary exercise testing (CPX). Association between exercise capacity and mortality is independent from degree of coronary artery disease. A large cohort study reported that each 1-METs increase was associated with a 12% improvement in survival [20]. Furthermore, the peak VO_2 is criteria of heart replacement. CAD patients who have less than 14 ml/min/kg of peak VO_2 are recommended to receive heart replacement according to European Society of Cardiology (ESC) guidelines [21]. In addition, minute ventilation/carbon dioxide production (VE/VCO_2) slope, which is obtained by CPX, have also demonstrated promise as a highly prognostic marker [22,23] CAD patients who have 35 or more of VE/VCO_2 slope have a three-fold higher risk of mortality compared to those who have less than 34 [22-24]. A meta-analysis of the prognostic markers of CPX demonstrates that peak VO_2 and VE/VCO_2 are strongly associated with mortality [25].

Practice of aerobic training

The intensity of aerobic training is very important if we want that CAD patients undergo exercise-based CR safely. The best way to determine the intensity is peak VO_2 or anaerobic threshold (AT) obtained from the cardiopulmonary exercise test using respiratory gas analyzer [3]. Forty to 70% of peak VO_2 or AT point has been recommended for aerobic training [3,26]. If CPX cannot be carried out, there is another way to determine the intensity of aerobic training. Forty to 60% of heart rate reserve or Karvonen method is applied if maximum exercise test is available. If the patients cannot perform any exercise test, we will determine the intensity using Borg scale of 6 to 20. Appropriate intensity is a rating of perceived exertion of 11-16 on a scale of Borg scale

according to some guidelines [3,26]. It is most effectiveness to carry out aerobic training for 30 minutes per session, more than 3 times per week and more than 3 months.

We will prescribe aerobic interval training when the patients cannot carry out the continuous aerobic training because of decreased skeletal muscle strength [26]. Interval training is composed of intense exercise periods and lower intensity recovery periods, alternately [27]. Originally, interval training was developed for the athletes because it improved exercise capacity and physical performance more rapidly than traditional continuous training. However, interval training has prescribed for CAD patients since 1990 years [28]. In an exercise-based CR field, interval training including intermitted rest periods has been applied more frequently to CAD patients with weakness. Although interval training is very effectiveness for CAD patients, it is unclear what should be the most appropriate method of establishing high and low intensity, and exercise and recovery periods. According to the ESC guideline, each session included four 4 min bouts of high intensity exercise, which was 90-95% of their maximal exercise capacity, interspersed with 3 min recovery periods at low intensity [26]. If CPX cannot be carried out, we determine the intensity of interval training using Borg scale when we prescribe the interval training for CAD patients.

RESISTANCE TRAINING

Evidence of skeletal muscle strength

As reduced cardiac output and tissue hypoxia in CAD induce expression of myostatin [29] and inflammatory cytokines [30], leading to the progressive decline of skeletal muscle mass [30]. Resistance training, that is strength training using weight lifting or machine training, is more likely to be an effectiveness intervention for CAD patients with poor skeletal muscles [26,31] In fact, according to a previous cross-sectional study by our group, muscle strength of CAD patients is approximately 70% of well-functioning, community-dwelling people regardless of age and sex [18]. In addition, some cohort studies showed that decrease of upper and lower extremity muscle strength was closely associated with all-cause mortality and cardiovascular mortality in CAD patients [32-34]. Furthermore, our meta-analysis demonstrated that resistance training alone much improved muscle strength and exercise capacity of all aged CAD patients, and mobility of elderly CAD patients compared with usual care [31]. These findings suggest that CAD patients, especially elderly patients, need to receive the resistance training program. CAD patients, who have undergone surgery and had prolonged bed stay in the intensive care unit (ICU) due to their severe conditions, often suffer from major functional impairments after discharge from ICU [35]. To solve this problem, some data suggests that resistance training started early may improve physical functions in ICU survivors [36].

Practice of resistance training

Resistance training is a muscular fitness program using weight lifting, machines with stacked weight or pneumatic resistance, and rubber bands [31]. Figure (1) shows the half squat and weight training with stacked weight. According to the American College of Sports Medicine's guidelines for exercise testing [37] and prescription or AHA guidelines [3], the intensity of resistance training is from 50% to 80% of the individual's one repetition maximum and the number of repetitions are from 8

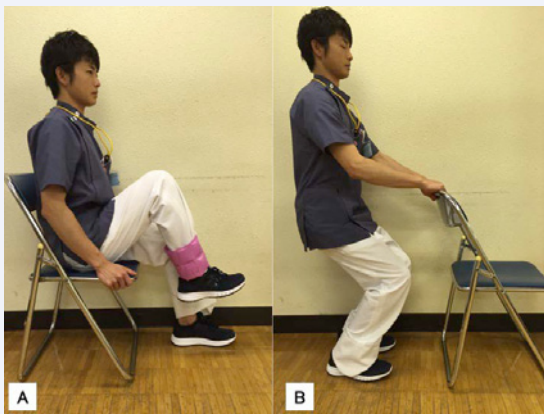


Figure 1 Resistance training; (A) weight training with stacked weight and (B) half squat.

to 15. Resistance training was applied to CAD patients for more than one month in our meta-analysis [31]. When we prescribe resistance training program for the CAD patients, we must monitor the electrocardiogram, vital sign and perceived exertion of patients [3]. Exercise intensity is maintained at a rating of perceived exertion of 11-16 on a scale of Borg scale. The number of elderly patients with sarcopenia or skeletal myopathy, that decrease skeletal muscle strength, has increased [30,38]. For patients who cannot undergo traditional resistance training, we usually prescribe neuromuscular stimulation (NMES, see Figure 2) [39-41]. The Cochrane meta-analysis reported that NMES was associated with improvement of peak VO₂ and 6-minuets walk distance for patients with heart failure [39]. In clinical practice, we often use NMES for CAD patients just after surgical operation or with mechanical ventilation. Furthermore, recent studies showed that resistance training with warming patients' muscles [42] or stretching exercise [43] were likely to be an effectiveness intervention for CAD patients with poor physical performance. The resistance training should be selected according to the condition or physical performance of CAD patients.

BALANCE TRAINING

Evidence of balance function

There is little evidence of balance function in CAD patients. In a cross-sectional study by our group, balance function of CAD patients, especially elderly patients, decrease 40% to 60% of age-matched healthy people in addition to muscle strength [18]. AHA and ESC guidelines recommend aerobic training and resistance training for CAD patients [2,3]. However they do not refer to the balance training. Our previous cross sectional study showed that decreased balance function was strongly associated with mobility for CAD patients, especially elderly patients [18]. Furthermore, deteriorated balance function is closely associated with fall risk [44-46]. Falls can lead to serious consequence, e.g. fracture and head injuries. Approximately 10% of falls result in a fracture,[47,48] which is a significant source of morbidity and mortality [49]. A three-year cohort study demonstrated that balance training was likely to be an affective intervention to improve mobility and reduced cardiac event for elderly CAD patients [19]. Collectively, deteriorated balance function associates with increased risk of low mobility, which leads to the decrease of physical activity that has a direct effect on

cardiovascular events and mortality.

Practice of Balance Training

There are many kind of balance training in rehabilitation. A Cochrane meta-analysis reported that types of balance training consist of parallel stance, tandem stance, single legged standing, tandem walk, balance boards and so on [50,51]. Therapists need to prescribe the training program according to individual's balance ability. We often select tandem stance and single legged standing training program according to the Cochrane Review (Figure 3) [50]. Tandem standing is defined as standing with one foot placed in front of the other with the heel touching the toe while the patient's eyes are open [50,19]. Patients were instructed to hold the one-leg standing and tandem standing positions without falling. If these training programs are easy for CAD patients, we should prescribe more difficult balance training programs. The tandem walk is one of balance training that walk on the line with one foot placed in front of the other with the heel touching the toe [50,52].

CONCLUSION

The main goals of exercise-based CR are to reduce mortality and re-admission. Furthermore, improvement or preservation of mobility is an important outcome for elderly patients with CAD, which is defined by the European Association of Cardiovascular Prevention and Rehabilitation as one of the main goals of cardiac rehabilitation for elderly CAD patients [17]. Some cohort studies showed that the low mobility was closely associated with an increase of mortality or re-hospitalization for CAD patients



Figure 2 Neuromuscular electrical stimulation by using belt electrode skeletal muscle electrical stimulation system (HOMER ION, Japan).



Figure 3 Balance training; (A) tandem stance standing and (B) single legged standing.

[19,53]. Several studies have shown that loss of physical functions including of skeletal muscle strength with advancing age, also known as sarcopenia of aging, is a highly prevalent condition among elderly people [54]. The deterioration of physical functions leads to the decrease of mobility that has a direct effect on health and survival. Some guideline recommended aerobic training using treadmill and cycle ergo meter, and resistance training. However, CAD patients with low mobility or elderly cannot carry out these traditional training programs. For this reason, we need to prescribe an appropriate training program, i.e. interval training, training using NMES or balance training, for each individual patient. We have researched the association with physical performance and cardiovascular events in CAD patients by meta-analysis of cohort studies [55]. We expect that therapists evaluate physical performances of CAD patients in addition to their clinical characteristics and cardiac functions, and make training programs individually.

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