Exercise Programming for Cardiovascular Disease

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Summary

Cardiovascular disease (CVD) remains the **number one** killer of adults worldwide. Regular physical activity has been identified as an effective treatment to improve physical function and reduce mortality in cardiac patients. The most common modality prescribed is aerobic training, although more recently resistance training and interval training have been introduced. These modalities enhance cardiac function, maximal oxygen uptake ($\text{VO}_{2\text{max}}$), and overall tolerance to exercise and improve health status.

Introduction: Epidemiology, statistics, and consequences of cardiovascular disease

Incidence of cardiovascular disease (CVD) is related to hypertension, obesity, and inactivity (1) and accounts for 26 % of all **annual** deaths in the United States (2). Annually, almost 800,000 adults suffer a first heart attack, and 470,000 suffer a subsequent heart attack (3). Care, treatment, and lost productivity **at work** from CVD lead to substantial health care costs equal to \$316.4 billion **per year** (3).

Exercise training has been shown to be a safe, effective strategy to rehabilitate persons with CVD as well as prevent CVD onset in high-risk individuals (4). Adaptations of chronic exercise include improved cardiac function represented by increases in stroke volume and cardiac output (5), vasodilation, and attenuated peripheral resistance **as well as increased** blood flow, $VO_2\text{max}$, and exercise tolerance. Moreover, these adaptations reduce morbidity and mortality in persons with CVD as well as those at risk for CVD.

The aim of this article will be to present current exercise guidelines to be used by exercise professionals in the primary prevention of CVD as well as for the outpatient rehabilitation of persons with existing CVD. In addition, sample exercise prescriptions for aerobic, strength, and interval training will be presented to be employed in this population.

Aerobic training

Aerobic training has long been prescribed to prevent CVD and serve as part of rehabilitation after an acute cardiac event. The American College of Sports Medicine and American Heart Association recommend 30 minutes per day of moderate-vigorous physical activity most days per week to obtain health-related benefits (6). Regular physical activity improves $VO_2\text{max}$, which is inversely correlated to mortality (6). Several recent reviews have described effects of

regular exercise during cardiac rehabilitation, but no universal exercise prescription was identified. In a review of 29 studies, Taylor and colleagues (7) concluded that 50 min of exercise training at 75 % VO_2max for 3 months (3.7 sessions per week) reduced mortality by 20 % and induced favorable decreases in low-density lipoprotein (LDL), total cholesterol, triglycerides, and systolic blood pressure. In another review article of 47 studies consisting of over 10,000 patients randomized to exercise-based rehabilitation or usual care, Heran et al. (8) demonstrated that 6 – 12 months of exercise training decreased cardiac mortality by 26 % and hospital admissions by 31 %. Fletcher et al. (9) reported that completion of physical activity > 4 METs was strongly associated with decreased cardiac mortality. Ultimately, the authors recommended 20 - 60 minutes of exercise 3 - 5 days per week at 50 - 70 % HRmax (40 - 60 % VO_2max /12 - 16 Borg Rating of Perceived Exertion (RPE)). This is similar to the minimum exercise intensity recommended by Swain and Franklin equal to 45 % of the VO_2 reserve (VO_2R).

In patients with chronic heart failure who completed three 40 minute sessions of cycling at 60 % VO_2max per week for 8 weeks, followed by 2 days per week of exercise for 12 months at the same intensity and duration, VO_2max was enhanced by 21% and was correlated with improved quality of life (Belardinelli). Compared to the control group, exercisers had 42 % less cardiac events, 23 % less cardiac deaths, and were 71 % less likely to be readmitted to the hospital for cardiac symptoms. Although long-term randomized controlled trials and cohort studies are lacking, data show that chronic exercise improves fitness, health status, and quality of life in cardiac patients. An example of a prospective aerobic training regime for stable cardiac patients, such as those with angina, heart failure, or previous stent implantation, myocardial infarction, or coronary artery bypass graft as well as individuals at risk for CVD is shown in Table 1.

Exercise professionals should emphasize that aerobic exercise including walking can improve fitness and reduce CVD risks and onset of potential complications. However, a minimum of 150 minutes per week is recommended to elicit health benefits, and there is a clear dose-response relationship in that more exercise provides greater benefits (6). This may be impractical for persons recovering from a cardiac event or those who were previously sedentary. These individuals may fatigue quickly, and the discomfort associated with exercise may decrease desire to perform subsequent exercise, thereby attenuating adherence. Overall, a minimum of 30 minutes per day of moderate aerobic exercise, to be completed in a single bout or as multiple shorter bouts, is recommended to prevent CVD onset as well as promote recovery in persons with existing heart disease.

Resistance training

Despite previous fears that resistance training (RT) would cause cardiovascular complications (12), it is now acknowledged as an important component of cardiac rehabilitation. Physiological adaptations of RT include improved muscle strength (13), bone density (14), and exercise tolerance as well as increased mood, independence, and quality of life (15) and attenuated blood pressure (16) and visceral fat (17). However, less is known about its safety and efficacy in high risk cardiac patients such as those with uncontrolled hypertension and/or arrhythmia (Wenger 1995).

Resistance training should be initiated approximately 3 weeks post-stent implantation or up to 5 week post-bypass surgery or heart attack, as long as patients have completed up to 4 weeks of supervised aerobic training (18). In addition, there are reports (Wilke 85) that activity equivalent to carrying 30 pounds is safe in heart attack patients only 3 weeks after the event. Regular

monitoring of HR and BP during each session is advised to ensure that cardiovascular responses to exercise are normal. A special consideration for coronary artery bypass graft patients is to avoid heavy loads being placed upon the chest to allow for proper sternal healing (Pollock et al 2000). Initial focus of exercise should be on high repetitions at low loads to promote muscle endurance. Low risk patients (American Heart Association-American College of Cardiology class B = asymptomatic) can perform RT under supervision of non-medical personnel; whereas, high-risk clients (class C = current or prior heart failure) should be monitored by medical personnel (9). Williams et al. (19) developed absolute and relative contraindications for RT in patients with CVD, which are outlined in Table 2. However, exceptions to these guidelines based on clinical judgment can be considered on a patient-by-patient basis.

In low-risk patients with CVD, loads between 8 – 15 repetition maximum (RM) have been deemed safe (19). Initial loads should be equal to 50 – 60 % 1-RM for the lower extremities and 30 - 40 % 1-RM for the upper extremities, and intensity should be increased by 5 % when clients complete 2 – 3 sets of 12 – 15 repetitions at a given load (18). However, low-risk persons with CAD experienced in resistance training can progress to higher intensities if desired (18), especially if they reveal hemodynamic stability and if other comorbidities (diabetes, etc.) do not occur or worsen in severity. One-repetition maximum testing is not recommended to determine true 1-RM, as clientele should be training to moderate fatigue and not exhaustion. Clients should perform 1 – 2 sets of 8 – 10 exercises for all major muscle groups 2 – 3 days per week, with 48 hours between sessions (18). Table 3 provides a sample RT program for persons with stable CVD. Recovery between sets ranges from 30 - 120 seconds depending upon the load performed (18). The Borg 6 – 20 RPE scale (20) can be used to monitor intensity during RT, with desired effort ranging from 11 (fairly light) – 14 (somewhat hard). Alternatively, the OMNI 0 – 10 RPE

scale () can be used to gauge intensity during resistance training. Overall, regular resistance exercise targeting the entire body is an important component of exercise training for CVD patients as well as those at risk for heart disease.

High intensity interval training

Interval training (IT) consists of repeated high-intensity bouts of short-duration interspersed with a brief recovery. Typically, bouts are performed at intensities between the lactate threshold and VO_2max , so individual bouts cannot be maintained for long periods due to metabolite accumulation (hydrogen ion and inorganic phosphate) and gradual depletion of phosphocreatine. Two primary advantages of interval training are that bouts are shorter in length than aerobic training, and amount of adaptations surpasses that of aerobic exercise (5,22).

In 1981, Ehsani et al. (20) conducted the first study examining effects of 1 yr of training on individuals who were post-MI. Men completed 3 months of training (3 days per week at 50 – 70 % VO_2max for 30 minutes) followed by 9 months (4 – 5 days per week) of continuous exercise at 70 – 80 % VO_2max accompanied by 2 – 3 2 – 5 minute bouts per day at 80 – 90 % VO_2max , for a duration of 50 – 60 minutes. Results showed a 34 % improvement in VO_2max , lower resting and exercise heart rate, and higher intensities at which ST segment depression occurred. Their follow-up study (21) revealed similar changes in VO_2max (+42 %), blood pressure, and improved left ventricular function.

Rognmo et al. (22) compared adaptations between IT and aerobic training (AT) consisting of treadmill walking in patients with heart disease. Over a 10 week period, participants completed 3 days per week of either 41 minutes of AT at 50 – 60 % VO_2peak (65 – 75 % HRmax) or 33 minutes of IT consisting of 4 bouts (up to 4 minutes long) at 80 – 90 % VO_2peak (85 – 95

%HRmax) interspersed with a 3 minute recovery at 50 – 60 %VO₂peak. Despite similar compliance and RPE across modalities, the increase in VO₂max was more than twofold greater with IT (+ 17.9 %) versus AT (+ 7.9 %). Warburton et al. (23) randomly assigned men with CAD to perform exercise 2 days per week (30 minutes per day) for 16 weeks of either IT (2 minutes at 85 – 95 %HRR separated by 2 minutes at 35 – 45 %HRR) or AT (65 %HRR) using the treadmill, stairclimber, and combined arm/leg exercise. Both groups of men also completed 3 days per week of AT at 65 %HRR for 30 minutes. Improvements in VO₂max were similar between groups, although increases in ventilatory threshold and time to exhaustion were greater with IT versus AT. Data in heart failure patients (24) completing 3 days per week of IT (up to 4 bouts at ~95 %HRmax interspersed with 3 minutes of recovery at 70 %HRmax) or AT (47 minutes at 70 %HRmax) for 12 weeks revealed similar results, including a three-fold greater improvement in VO₂max with IT (+ 46 %) compared to AT (+ 14 %). Overall, up to three IT sessions per week consisting of up to four bouts at intensities approaching 95 %HRmax may promote greater improvements in functional capacity which in the long run may allow patients to better tolerate strenuous activities inherent in day-to-day life. However, little is known about the long-term safety and efficacy of interval training in this population, although over 2,000 hours have been completed in Norway without incidence of adverse event (Wisloff 2009 ESSR). Moreover, existing data were obtained in relatively stable, low-risk individuals, so whether this modality should be implemented in high-risk persons remains to be determined.

Conclusion

Cardiovascular disease is widespread across the world. Regular exercise has been shown to be a safe and effective strategy to prevent CVD and reduce its severity. Exercise professionals should consider the following recommendations when working with this clientele:

1. Adaptations obtained with regular exercise include improved VO_2max and exercise tolerance, cardiac function, and attenuated blood pressure which improve clients' risk profile.
2. Aerobic training should be completed a minimum of 3 days per week for 30 minutes at intensities between 50 - 70 % VO_2max or 50 - 75 % HRmax .
3. Total-body resistance training should be performed 2 – 3 days per week at loads between 30 – 60 % 1-RM. Clients should avoid the Valsalva maneuver during exercise.
4. Interval training at intensities between 80 – 90 % $\text{VO}_2\text{max}/\text{HRmax}$ is superior to aerobic training to improve VO_2max and heart function. It is **often** perceived to be more enjoyable than aerobic training and typically requires less time.

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