

Exercise Training in Chronic Heart Failure: A Sea Change



Over the past 15 years there has been increasing evidence that encouraging rest and restricting physical activity can be counterproductive, and that a medically prescribed exercise training regimen helps to alleviate symptoms, improve exercise tolerance, and enhance quality of life.

By Dr. Terence Kavanagh, MD, FRCPC



Dr. Terence Kavanagh, MD, FRCPC, is professor, graduate program in exercise sciences, faculty of physical education & health and associate professor, department of medicine, at the University of Toronto, Toronto, Ont.

Introduction

The prevalence and incidence of chronic heart failure (CHF) has increased dramatically over the past four decades—the product of an aging population and an improved survival rate for patients with severe ischemic heart disease. In North America, it is estimated that about five million patients suffer from CHF, with 400,000 new cases diagnosed every year.¹

Table 1:

Reported Benefits of Exercise Training in CHF

- Improved exercise capacity (increased peak oxygen intake)
- Reduced breathlessness (lactate threshold increases)
- Reduced submaximal heart rate
- Increased cardiac output
- Improved autonomic control (as determined by heart rate variability and power spectral analysis)
- Improved skeletal muscle oxidative capacity
- Improved endothelial function
- Improved myocardial function
- Improved mood and quality of life

The mainstays of treatment have included:

- Enforced bedrest;
- Salt-free diet; and
- Digoxin.

More recent additions to the drug armamentarium include:

- Vasodilators;
- Inotropes;
- Angiotensin-converting enzyme inhibitors; and
- Beta-blockers.

Over the past 15 years, there has been increasing evidence that encouraging rest and restricting physical activity can be counterproductive, and that a medically prescribed exercise training regimen helps to alleviate symptoms, improve exercise tolerance, and enhance quality of life.

The previous reluctance of physicians to consider exercising heart failure patients is understandable, realizing that an acute bout of exercise has the potential to increase wall stress, trigger an abrupt rise in the secretion of neurohormones, and have a negative effect on

myocardial remodeling. This concern was fuelled by an early publication from Jugdutt and co-workers, which concluded that to exercise patients who had reduced ventricular function as a result of a large anterior infarct could lead to wall thinning, infarct expansion, further asynergy, and a reduction in ejection fraction.² Subsequently, however, two well-designed randomized clinical trials by Gianuzzi and co-workers not only demonstrated that beneficial training effects could be obtained without adversely affecting remodeling, but also that a structured exercise rehabilitation program could actually attenuate the remodeling process.^{3,4} Analysis of the data from subsequent studies confirmed these findings apply to patients with ischemic and non-ischemic cardiomyopathy, as well as those with moderate and even severe left ventricular dysfunction.^{5,6} Thus, the weight of evidence favors the view that exercise training is safe in patients with stable chronic heart failure.

“Reduced physical activity is critical in the care of patients with chronic heart failure throughout their entire course.”

Heart Disease: A Textbook of Cardiovascular Medicine. Third Edition. Braunwald E. (ed). WB Saunders Company, Philadelphia, 1988.

“Heart failure patients...tend to have significant improvement with exercise training, and supervised training has shown to be safe.”

Heart Disease: A Textbook of Cardiovascular Medicine. Fifth Edition. Braunwald E. (ed). WB Saunders Company, Philadelphia, 1997.

Benefits of Exercise Training

In the late 1980s, Sullivan and co-workers from Duke University were the first to report their experience with exercise training in CHF patients.^{7,8} They were able to show significant improvement in exercise tolerance, alleviation of breathlessness, and an increase in leg blood flow. In 1992, the first randomized cross-over trial of exercise in CHF was carried out by Coats and the Oxford group. This demonstrated an improvement in exercise duration, as well as an alleviation of the symptoms of breathlessness and fatigue.⁹ Later, a series of exercise trials confirmed these results and described further impressive beneficial changes (Table 1).

Possible Mechanisms by Which Training Improves CHF Symptomology

Central

Since the primary cause for CHF is impairment of the heart's pumping function, it seems reasonable to assume that a) the symptoms of fatigue and breathlessness are central in origin and b) any therapy (including exercise) that relieves symptoms does so by improving ven-

tricular function. However, we know that increasing cardiac output by the use of inotropes results in only a slight increase in exercise capacity.¹⁰ Similarly, heart transplant recipients, despite normal systolic function, continue to show a reduced peak power output and oxygen intake on cycle ergometry for as long as 12 months after surgery.¹¹ Finally, left ventricular ejection fraction has been shown to have a poor correlation with exercise capacity.¹² It is, therefore, unlikely that the benefits achieved by exercise training can be attributed to an improvement in central hemodynamics.

Skeletal Muscle

Muscle weakness and wasting, together with histological evidence of alterations in fibre type and function, are features of CHF. This may be due, in part, to de-conditioning, or possibly to elevated levels of norepinephrine and/or tissue necrosis factor alpha.¹³ A number of studies have demonstrated these abnormalities can be at least partially reversed by exercise training. Stratton and co-workers, using magnetic resonance spectroscopy and utilizing single-limb forearm training, were able to show a training-induced increase in exercise duration which correlated with an increase in muscle oxidative enzyme activity.¹⁴ Similar results were obtained by Hambrecht and colleagues using stationary

cycle training.¹⁵ This is consistent with the hypothesis that at least part of the muscle metabolic defects are due to local muscle deconditioning, and that this can be reversed even without a change in underlying cardiovascular function.

Pulmonary Function

Early investigators attempted to attribute the severe dyspnea seen during exercise in CHF patients to changes in the lung. However, pulmonary wedge pressure was found to be poorly correlated with exercise tolerance.¹⁶ Further, most studies show that in patients with CHF, arterial blood gases remain normal during a bout of exercise.¹⁷ Other explanations include a mismatch of pulmonary ventilation and perfusion leading to an increase in dead space, and/or weakness of respiratory muscles. While these might apply in some cases, the fact that exercise training can alleviate effort dyspnea suggests the fault lies in the periphery. Increased muscle lactate production at low exercise levels is one likely candidate.¹⁸ Another is up-regulation of arterial chemoreceptors and muscle ergoreceptors.¹⁹

Autonomic Nervous System

The failing heart triggers a series of compensatory mechanisms which are designed to maintain an adequate circulation, but which ultimately are self-defeating. There is a marked activation of various neurohumoral mechanisms, including an elevation in catecholamine levels²⁰—an adverse prognostic indicator for survival.²¹ Studies carried out in the 1970s demonstrated training could reduce resting and exercise norepinephrine levels in both healthy adults²² and in individuals recovering from a myocardial infarction.²³ Later, the group from Oxford



described a training-induced reduction in norepinephrine in CHF patients. They also reported an increase in heart rate variability, indicating a reduction in sympathetic and an increase in vagal (parasympathetic) tone.²⁴ More recently, Shemesh and co-workers reported a training-induced decrease in norepinephrine and atrial natriuretic peptide levels, both at rest and during exercise.²⁵ Given the potential for these changes to raise the threshold for ventricular fibrillation, they could prove to be important in preventing sudden cardiac death.

Peripheral Blood Flow

CHF is associated with poor delivery of blood to the periphery during exercise—the result of a decline in the production of nitric oxide, reduced flow, and impaired arteriolar vasodilation. Improvement in endothelial function and nitric oxide synthesis in brachial and femoral arteries has been shown as a result of isolated limb training²⁶ and following a whole-body aerobic conditioning program.²⁷ Of late, Hambrecht and co-work-

Table 2:

Training Protocols in 10 Clinical Trials of Exercise in CHF

| | |
|-----------------------------|---|
| Mode: | Stationary cycle (7)*, walking (5), stair machine (2), rowing machine (1), calisthenics (1), resistance training (3) |
| Intensity: | 40% - 70% peak oxygen intake 60% - 80% maximum heart rate Borg Rating of Perceived Exertion 11-13 (between “fairly light” and “somewhat hard”) |
| Frequency: | 3 to 7 times per week (average 3 -4 x/wk) |
| Duration: | 15 to 45 minutes |
| Interval Training: | Walk-rest 2 to 3 min/1 min or stationary cycle/rest 30 - 60 sec/60 sec |
| Resistance Training: | Leg press, 2 sets of 10 repetitions, 60% to 80% of max. voluntary contraction. Isometric muscle contractions are contraindicated. |

NB: Full cardiological assessment is mandatory prior to entering an exercise program.
*Numbers in parentheses indicate the number of studies using that mode of exercise.

Table 3:

Criteria for Modifying or Stopping Exercise Training in CHF Patients

- Weight gain >4 lb (1.8 kg) over preceding two days
- Resting heart rate >110 bts.min⁻¹
- SBP fails to rise or falls >10 mm Hg with exercise
- Excessive dyspnea
- Excessive fatigue
- Increasing exercise-induced ectopy
- Pulmonary edema (rales)
- Development of abnormal heart sounds (S₃ gallop, regurgitant murmurs)

ers reported similar training-induced improvement in the coronary arteries of CHF patients.²⁸

far, however, there is insufficient published information on the topic to warrant the routine use of this modality.

The Exercise Program

Exercise testing, with direct measurement of respiratory gases, provides a more accurate assessment of New York Heart Association (NYHA) functional classification, compared to clinical history alone. It is the preferred screening procedure for entry into a CHF exercise rehabilitation program.²⁹ In view of the CHF patient's low exercise tolerance, the testing protocol should call for low starting intensities and workload increments. An alternative method of measuring functional capacity is the six-minute walk test.³⁰ This test, however, is probably more suited to checking progress than initiating exercise therapy.

To date, there is no established gold standard for exercise training CHF patients, although guidelines have been published by a number of authoritative bodies.³¹⁻³⁴ Most programs have employed aerobic-type exercise (Table 2). Interval-type training may be more appropriate in the early stages.³⁵ As for the optimal length of a program, a Toronto study determined that optimal physiological and quality of life gains have been achieved by six months, after which they plateau.³⁶

The muscle wasting associated with CHF suggests the need for resistance-type weight training, and there is recent evidence to the effect that this imposes no greater hemodynamic strain than aerobic activities.^{37,38} So

Safety

Evidence to date suggests it is safe to exercise clinically stable NYHA Class II and III CHF patients who are free from angina and malignant arrhythmias. Initially, the program should take place in a medical setting with staff that is experienced in the recognition of adverse signs and symptoms (Table 3). Unsupervised additional sessions can be allowed when the individual is judged to be exercising prudently and at the prescribed level.



Patient Selection

Exercise training is advisable only in stable chronic heart failure. Absolute con-

traindications are listed in Table 4. While there is no minimum left ventricular ejection fraction standard for training, the mean values reported by the various trials range from 18% to 35%. Wilson and co-workers have delineated a subset of patients who fail to obtain benefit from training because their major limiting feature is a poor cardiac output response to exercise, rather than poor peripheral function.³⁹

Class IV patients have been less frequently included in training studies, although they comprise 20% of a group which Belardinelli and colleagues recently reported as having lower mortality and morbidity rates following a one-year moderate (60% peak VO_2) aerobic training program.⁴⁰

Table 4:
Contraindications to Exercise Training in CHF Patients

- Significant ischemia (angina or ST-segmental depression) at low-level workloads
- Moderate to severe aortic stenosis
- Malignant ventricular arrhythmias
- Acute pericarditis or myocarditis
- Regurgitant valvular heart disease requiring surgery

Conclusion

It is now apparent that substantial training benefits can be achieved in patients with stable CHF. However, the number of patients involved in randomized clinical trials is still relatively small, and there is a need for large multicentre trials, preferably international in scope. These would provide definitive answers to questions regarding appropriate training regimens, precise selection of patients, mortality, and cost benefit.

fits.

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