

New frontiers in exercise training and testing¹

Jean-Paul Schmid

Cardiovascular Prevention & Rehabilitation, Swiss Cardiovascular Centre Bern, University Hospital (Inselspital), Switzerland

Summary

In the last few years, several new concepts concerning exercise training and prescription in cardiac patients have emerged and new guidelines have been published. The general trend goes in the direction of more intensive exercise training to optimise its effect. Thereby, the focus is not only on improvement in exercise capacity, but also on structural changes of the myocardium and optimal weight loss. This review addresses practical aspects of these new concepts.

Key words: Exercise training; cardiac rehabilitation; interval training; heart disease

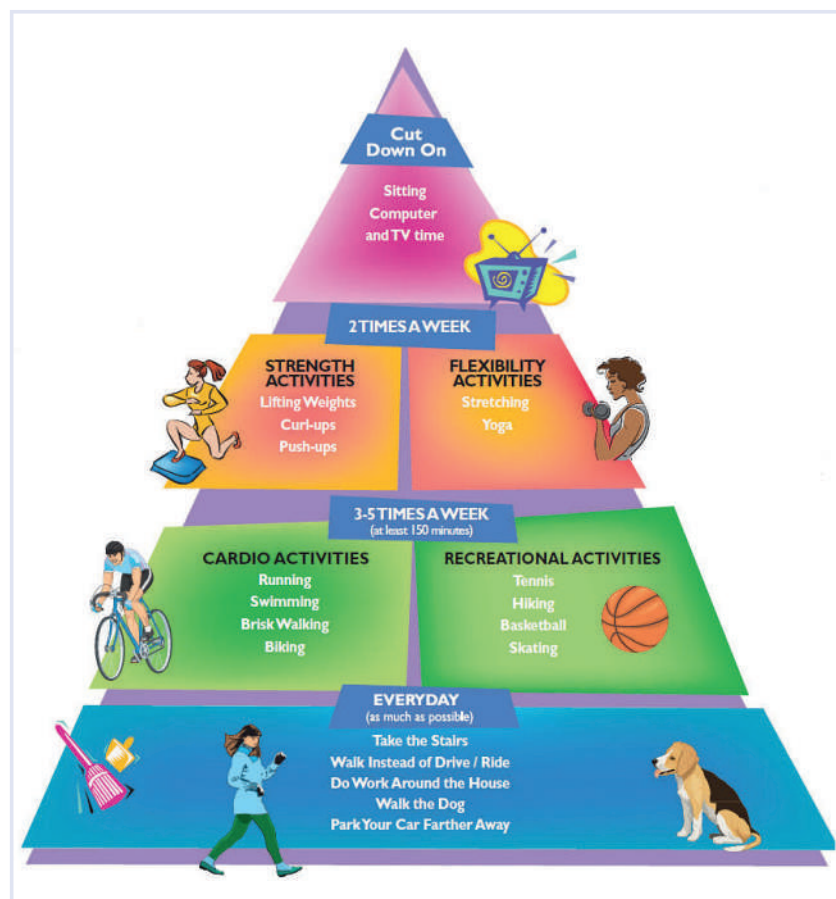
New frontiers in exercise training and testing

Regarding exercise training and prescription in cardiac patients, several new concepts have emerged during the last few years. Concerning exercise testing, no substantial changes have occurred. Recently, the “American College of Sports Medicine” has released their new guidelines, which serve as a reference for exercise testing and prescription [1] for many health- and fitness-professionals and which addresses some of these new trends. Last updated in 1998, the most important changes of content are the following:

- New guidelines for Body Mass Index and percent-body-fat classifications.
- New table explaining abnormal exercise test findings.

Figure 1

Activity pyramid. (Adapted from: “The Activity Pyramid” © ParkNicolletHealthSource®, Minneapolis, U.S.A. used with permission.)



- Introduction of the “activity pyramid” as a general rule for exercise prescription, using a concept similar to the food pyramid in order to provide an easy method to advocate physical activity (fig. 1).
- Greatly expanded section focusing on prescription guidelines for both the elderly and children, along

Funding / potential competing interests: No financial support and no other potential conflict of interest relevant to this article was reported.

1 Lecture at the annual meeting of the Swiss Society of Cardiology, Swiss Society of Sports medicine, Swiss Society of Paediatric Cardiology, Swiss Society of Thoracic and Cardiovascular Surgery and the Swiss Society of Hypertension; June 8–6, 2011.

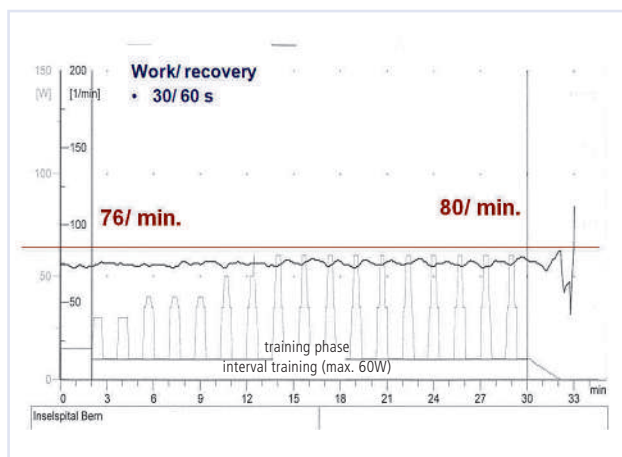
Correspondence:
Jean-Paul Schmid, MD
Cardiovascular Prevention & Rehabilitation
Swiss Cardiovascular Centre Bern
University Hospital (Inselspital)
CH-3010 Bern
Switzerland
jean-paul.schmid[at]insel.ch

with addressing the topic of increasing physical activity in schools and communities.

- A new chapter on how to address ways to increase compliance and to decrease risk factors.

Figure 2

Example of an interval training session of 30 minutes at low intensity in a 68-year-old patient with ischaemic heart disease and systolic dysfunction (EF: 35%). There is hardly an increase in heart rate with this training modality. The functional parameters of the symptom limited exercise stress test were: peak VO_2 16.1 ml/kg/min, peak work rate 110 W, peak heart rate 128/min.



- A new chapter on the use of informed consent, licensing, and proper supervision for exercise tests. Furthermore a position stand, entitled “Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise” including specific recommendations on aerobic exercise, strength training and flexibility has also been recently published [2]. The table below summarises the basic recommendations.

In addition to outlining basic recommendations and their scientific reasoning, the position stand also clarifies the following new aspects:

- Pedometers, step-counting devices used to measure physical activity, are not an accurate measure of exercise quality and should not be used as the sole measure of physical activity.
- Though exercise protects against heart disease, it is still possible for active adults to develop heart problems. All adults must be able to recognise the warning signs of heart disease, and all health care providers should ask patients about these symptoms.
- Sedentary behaviour – sitting for long periods of time – is distinct from physical activity and has been shown to be a health risk in itself. Meeting

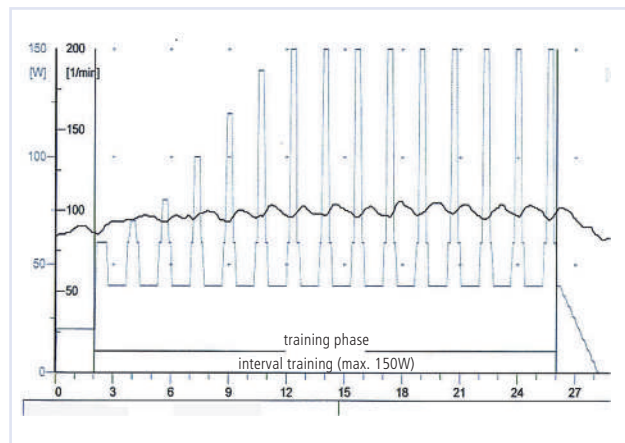
Table 1

Recommendations for physical activity, categorised by cardio-respiratory exercise, resistance exercise, flexibility exercise and neuromotor exercise.

Cardio-respiratory exercise	<ul style="list-style-type: none"> – Adults should get at least 150 minutes of moderate-intensity exercise per week. – Exercise recommendations can be met through 30–60 minutes of moderate-intensity exercise (five days per week) or 20–60 minutes of vigorous-intensity exercise (three days per week). – One continuous session and multiple shorter sessions (of at least 10 minutes) are both acceptable to accumulate desired amount of daily exercise. – Gradual progression of exercise time, frequency and intensity is recommended for best adherence and least injury risk. – People unable to meet these minimums can still benefit from some activity.
Resistance exercise	<ul style="list-style-type: none"> – Adults should train each major muscle group two or three days each week using a variety of exercises and equipment. – Very light or light intensity is best for older persons or previously sedentary adults starting exercise. – Two to four sets of each exercise will help adults to improve strength and power. – For each exercise, 8–12 repetitions improve strength and power, 10–15 repetitions improve strength in middle-age and older persons starting exercise, and 15–20 repetitions improve muscular endurance. – Adults should wait at least 48 hours between resistance training sessions.
Flexibility exercise	<ul style="list-style-type: none"> – Adults should do flexibility exercises at least two or three days each week to improve range of motion. – Each stretch should be held for 10–30 seconds to the point of tightness or slight discomfort. – Repeat each stretch two to four times, accumulating 60 seconds per stretch. – Static, dynamic, ballistic and proprioceptive neuromuscular facilitation stretches are all effective. – Flexibility exercise is most effective when the muscle is warm. Try light aerobic activity to warm the muscles before stretching.
Neuromotor exercise	<ul style="list-style-type: none"> – Neuromotor exercise (also called “functional fitness training”) is recommended for two or three days per week. – Exercises should involve motor skills (balance, agility, coordination and gait), proprioceptive exercise training and multifaceted activities (Tai Chi and yoga) to improve physical function and prevent falls in older adults. – 20–30 minutes per day is appropriate for neuromotor exercise.

Figure 3

Example of an interval training with high workload in a 48-year-old patient with ischaemic heart disease with slightly reduced left ventricular ejection fraction (EF: 50%). Heart rate increases only modestly (<20 beats/min). The functional parameters of the symptom limited exercise stress test were: peak work rate 180 W, peak heart rate 154/min.



the guidelines for physical activity does not make up for a sedentary lifestyle.

Regarding exercise prescription for cardiac patients, evidence for two major principles is increasing, namely:

1. High intensity interval training (bouts of 90 to 100% of heart rate reserve) vs lower intensity, interspersed with rest (minimal threshold) for equal time periods.
2. High-calorie-expenditure exercise to promote weight loss.

High intensity interval training

Interval training, the alternation of workload and recovery for short time periods has been introduced in cardiac rehabilitation services many years ago as a training modality suitable for patients with advanced heart failure (NYHA class III). This type of training allowed also in severely deconditioned patients to impose a muscular stimulus high enough to elicit a metabolic effect with adequate recovery time. Furthermore, the cardiovascular response to this type of training is only modest, even at a high intensity (fig. 2 and 3).

Initially introduced as a low intensity interval training, Kemi et al. [3] wondered whether a high intensity interval training could induce larger benefits in fitness and maximal oxygen uptake (VO_2 max). For this purpose, he assessed the effectiveness of a 10-week training period in an animal model. Rats performed treadmill running intervals at either 85–90% or 65–70% of VO_2 max 1 h per day, 5 days per week with weekly adjustment of exercise intensity. High intensity training led to a more pronounced effect on VO_2 max, paralleled by an intensity-dependent cardiomyocyte hypertrophy and an increased cardiomyocyte function.

Based on the fact that cardiovascular adaptations to training seemed to be intensity-dependent, Wisloff et al. [4] then randomised 27 patients aged 75.5 ± 11.1 years with stable post-infarction heart failure to either moderate continuous training (70% of highest measured heart rate) or aerobic interval training (95% of peak heart rate, fig. 4) 3 times per week for 12 weeks or to a control group. VO_2 max increased more with high intensity interval training than moderate continuous training and, more important, was associated with reverse LV remodelling, confirming the effect of high intensity training on cardiomyocyte function seen in the animal model.

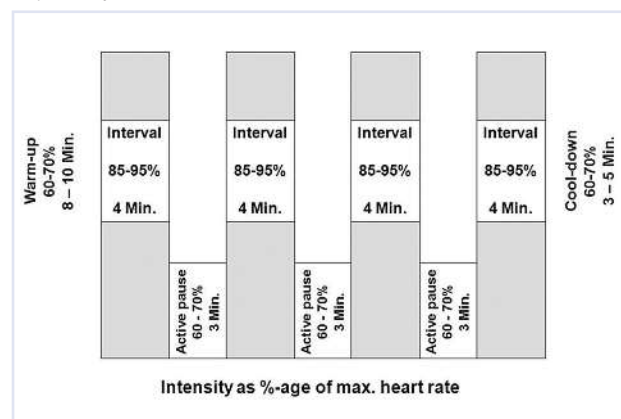
It might therefore be that cardiovascular adaptations to training are intensity-dependent with a significantly higher benefit of high intensity in VO_2 max, cardiomyocyte dimensions and contractile capacity as well as endothelial function. The first experience in humans also suggests, that high intensity interval training can be effectuated safely in a population of elderly heart failure patients. However, long term effect of this type of exercise on left ventricular remodeling is still missing. Furthermore, four minutes periods of high workload interval constitute an important challenge and it remains to be shown whether this type of exercise will become accepted and/or whether shorter intervals are equally effective.

High-calorie-expenditure exercise

A high percentage of patients entering cardiac rehabilitation are overweight, and/or have a metabolic syndrome. Current cardiac rehabilitation exercise protocols result in little weight loss. Along with dietary counseling, Ades et al. [5] therefore evaluated the effect of high-calorie-expenditure exercise (3000 to 3500 kcal/week) compared with standard cardiac rehabilitation exercise (700 to 800 kcal/wk) on weight loss and risk factors in 74 overweight patients with coronary

Figure 4

High intensity interval training (according to the Norwegian model) with long periods of work/recovery (4 minutes and 3 minutes, respectively).



heart disease. High-calorie-expenditure exercise resulted in double the weight loss (8.2 ± 4 vs 3.7 ± 5 kg) at five months.

According to this observation, an optimal exercise based intervention for weight loss in cardiac patients should follow the principles cited below:

- Exercise prescription for the high-calorie-expenditure should emphasise:
 - longer-duration (45 to 60 vs 25 to 40 minutes per session)
 - lower-intensity (50% to 60% vs 65% to 70% peak VO_2)
 - more frequent (5 to 7 vs 3 times a week) exercise
- Walking should be the preferred exercise modality to maximise caloric expenditure vs weight-supported exercises (cycling or rowing), which burn fewer calories.
- The exercise expenditure goal of 3000 to 3500 kcal/week should be attained after 2 to 4 weeks of gradually lengthening the exercise bouts.
- On-site sessions for at least two weeks can be useful for motivation and instruction, as well as home exercise logs (reviewed regularly with the exercise physiologist to estimate caloric expenditure and to ascertain compliance).
- Individual or group counseling sessions emphasising dietary records, itemisation of food, and caloric content seem to be crucial in addition to regular physical activity.
- Daily caloric goal should be set 500 kcal less than predicted maintenance calories.

- Severely deconditioned patients are unable to follow a regular exercise training as proposed and need an individualised approach.
- Patients with orthopaedic problems, which occur often in obese patients, especially in the elderly, should be offered alternative exercise modalities like stepper, crosstrainer or aqua-jogging.

High-calorie-expenditure exercise promotes greater weight loss and more favourable the cardiometabolic risk profile than standard cardiac rehabilitation in overweight coronary artery patients. Therefore, if the main aim in a patient entering cardiac rehabilitation is weight loss, an individualised exercise prescription based on the concept “walk often and walk far!” should be adopted.

References

- 1 Thompson WR, et al., eds. ACSM's Guidelines for Exercise Testing and Prescription. 8th ed. Baltimore/USA: Lippinkott Williams & Wilkins; 2010.
- 2 Garber CE, et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc.* 2011;43:1334–59.
- 3 Kemi OJ, et al. Moderate vs high exercise intensity: differential effects on aerobic fitness, cardiomyocyte contractility, and endothelial function. *Cardiovasc Res.* 2005;67:161–72.
- 4 Wisloff U, et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. *Circulation.* 2007;115:3086–94.
- 5 Ades PA, et al. High-calorie-expenditure exercise: a new approach to cardiac rehabilitation for overweight coronary patients. *Circulation.* 2009;119:2671–8.